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ABSTRACT

The categorizations which humans make of the concrete world are not arbitrary but highly determined. In taxonomies of concrete objects, there is one level of abstraction at which the most basic category cuts are made. Basic categories are those which carry the most information, possess the highest category cue validity, and are, thus, the most differentiated from one another. The four experiments of Part I defined basic objects by demonstrating that in class inclusion taxonomies of common concrete nouns in English, basic objects are the most inclusive categories whose members: (1) possess significant numbers of attributes in common, (2) are used by means of similar motor programs, (3) possess shapes which are significantly similar, and (4) can be identified from averaged shapes of members of the class. The eight experiments of Part II explored some implications of the structure of categories. Basic objects were shown to be: (1) the most inclusive categories for which a concrete image of the category as a whole could be formed; (2) the first categorizations made during perception of the environment; (3) the earliest categories sorted and earliest named by children; and (4) the categories most codable, most coded, and most necessary in language. Universality and implications of the results were discussed. (Author/CLK)

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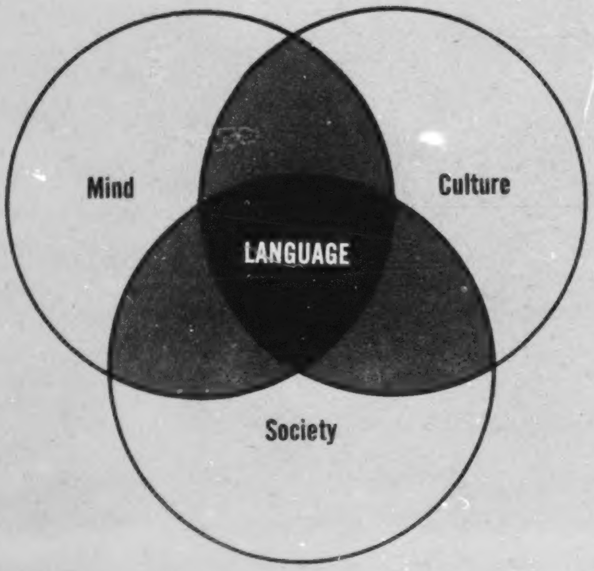

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BASIC OBJECTS IN NATURAL CATEGORIES

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Abstract

It is argued that the categorizations which humans make of the concrete world are not arbitrary but highly determined, and that, in taxonomies of concrete objects, there is one level of abstraction at which the most basic category cuts are made. Basic categories are shown to be those which carry the most information, possess the highest category cue validity, and are, thus, the most differentiated from one another. The four experiments of Part I defined basic objects by demonstrating that in class inclusion taxonomies of common concrete nouns in English, basic objects are the most inclusive categories whose members: (a) possess significant numbers of attributes in common, (b) are used by means of similar motor programs, (c) possess shapes which are significantly similar, and (d) can be identified from averaged shapes of members of the class. The eight experiments of Part II explored some implications of the structure of categories. Basic objects were shown to be the most inclusive categories for which a concrete image of the category as a whole could be formed, to be the first categorizations made during perception of the environment, to be the earliest categories sorted and earliest named by children, and to be the categories most codable, most coded, and most necessary in language. Universality and implications of the results were discussed.

BASIC OBJECTS IN NATURAL CATEGORIES

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The world consists of a virtually infinite number of discriminably different stimuli. One of the most basic functions of all organisms is the cutting up of the environment into classifications by which nonidentical stimuli can be treated as equivalent. Yet there has been little explicit attempt to determine the principles by which humans divide up the world in the way that they do. On the contrary, it has been the tendency both in psychology and anthropology to treat that segmentation of the world as originally arbitrary and to focus on such matters as how categories, once given, are learned or the effects of having a label for some segment. A typical statement of such a position is: "...the physical and social environment of a young child is perceived as a continuum. It does not contain any intrinsically separate 'things.' The child, in due course, is taught to impose upon this environment a kind of discriminating grid which serves to distinguish the world as being composed of a large number of separate things, each labeled with a name" (Leach, 1964, p. 34).

It is the contention of the present paper that such a view would be reasonable only if the world were entirely unstructured; that is, using Garner's (1974) definition of structure, if the world formed a set of stimuli in which all possible stimulus attributes occurred with equal probability combined with all other possible attributes. Thus, if the attributes were size (large, small), color (red, green), and form (square, circle), the set would consist of a small red square, a small red circle, a small green square, a small green circle, a large red square, etc. (In this example, to make the stimuli more of a continuum, we need only increase indefinitely the number of values for each attribute with a subsequent increase in possible combinations). While such stimulus arrays have been typically used in concept identification research (Bourne, 1968) and in many studies of free sorting behavior (Shepard, Hovland, & Jenkins, 1961; Wing & Bevan, 1969), they may not adequately represent the structure of stimuli in the real world.

The aim of the present research was to show that the world does, in a sense, contain "intrinsically separate things." The world is so structured because, in the first place, real-world attributes, unlike the sets often presented laboratory subjects, do not occur independently of each other. Creatures with feathers are more likely also to have wings than creatures with fur, and objects with the visual appearance of chairs are more likely to have functional sit-on-able-ness than objects with the appearance of cats. That is, if we imagine an n X n matrix of all possible attributes, combinations do not occur uniformly: for example, some pairs, triples...ntuples are quite probable, appearing in combination sometimes with one, sometimes another attribute; others are rare; others logically cannot or empirically do not occur.

In the second place, categories are determined because the world appears to be so structured that in taxonomies of concrete objects, there is generally one level of abstraction at which the most basic category cuts can be made. In general, the basic level of abstraction in a taxonomy is the level at which categories carry the most information, possess the highest cue validity, and are, thus, the most differentiated from one another. More specifically, the basic level of abstraction can be described both in general terms of cognitive economy and in the specific language of probabilistic cue validity (Brunswik, 1956).

With respect to general cognitive economy, the basic level is the level of abstraction at which the organism can obtain the most information with the least cognitive effort. That is, to categorize a stimulus means to consider it, for purposes of that categorization, not only equivalent to other stimuli in the same category but also different from stimuli not in that category. On the one hand, it would appear to the organism's advantage to have as many properties as possible predictable from knowing any one property (which, for humans, includes the important property of the category name), a principle which would lead to formation of large numbers of categories with the finest possible discriminations between categories. However, on the other hand, in so far as categorization occurs to reduce the infinite differences between stimuli to behaviorally and cognitively usable proportions, it is to the organism's advantage not to differentiate stimuli from other stimuli when that differentiation is irrelevant for the purposes at hand. The basic level of classification, the primary level at which cuts are made in the environment, appears to result from the combination of those two principles; it is the most general and inclusive level at which categories can delineate real-world correlational structures.

These intuitions about structure can be made more precise through the concept of cue validity. Cue validity is a probabilistic concept; the validity of a given cue x as a predictor of a given category y (the conditional probability of y/x) increases as the frequency with which cue x is associated with category y increases and decreases as the frequency with which cue x is associated with categories other than y increases. The precise mathematical form used to compute the conditional probability y/x has varied (Beach 1964a, 1964b; Reed, 1972). The power of cue validity in formation of the internal structure of categories has been demonstrated for both natural and for controlled artificial categories (Rosch & Mervis, in press). The cue validity of an entire category may be defined as the summation of the cue validities for that category of each of the attributes of the category. (Note that category cue validity is no longer a term within probability theory which cannot exceed 1).

A category with high cue validity is, by definition, more differentiated from other categories than one of lower cue validity. A working assumption of the present research has been that, in the domains of both man-made and biological objects, there occur information-rich bundles of perceptual and functional attributes that form natural discontinuities. It is proposed that basic cuts are made at this level. If basic objects (e.g. chair, car) are at the most inclusive level of categorization at which there can be many attributes common to all or most members of the category, basic objects will, thereby, be categories at the level of abstraction for which cue validities are maximized. That is, categories more abstract than the basic level whose members are themselves basic objects (e.g. furniture, vehicle) are superordinates which share only a few attributes among each other. Categories below the basic level are subordinates (e.g. kitchen chair, sports car) which are also bundles of predictable attributes and functions but which contain little more information than the basic level object to which they are subordinate. Superordinate categories have lower cue validity than basic because they have fewer common attributes within the category; subordinate categories have lower cue validity than basic because they share most attributes with contrasting subordinate categories (e.g. kitchen chair shares most of its attributes with other kinds of chairs). That basic objects are categories at the level of abstraction which maximizes cue validity is another way of asserting that basic objects are the categories which best mirror the correlational structure of the environment.

The present paper is divided into two major parts. In Part I, a series of converging experiments are reported whose purpose was to define further and to provide evidence supporting the concept of basic level objects. The experiments reported in Part II were intended to explore some of the implications which the concept of basic objects has for cognitive representations of categories, perception, the development of classifications, and for the linguistic usage and evolution of category labels.

PART I: CONVERGING OPERATIONAL DEFINITIONS OF BASIC OBJECTS

Basic objects are the most inclusive categories which delineate the correlational structure of the environment. However, real-world correlational structure itself consists of a number of inseparable aspects, any one of which could serve as the point of departure for the present analysis:

1. As has already been implied, basic level objects should be the most inclusive level of classification at which objects have numbers of attributes in common. Although in experimental psychology and in cultural anthropology as a whole, categories have generally been taken as arbitrary, a number of ethnobiologists have, for some time, asserted a claim somewhat similar to the claim of the present study--that there is a level of biological classification which corresponds to "natural groupings" of organisms which possess "bundles" of correlated features and which are "obviously" different from other organisms (Berlin, 1972; Bulmer, 1967; Bulmer & Tyler, 1968; Rosaldo, 1972). Berlin (1972) has gone considerably farther and argued an evolutionary theory of plant names. He identified the natural grouping at the level of the genus (oak, maple) and has amassed considerable evidence in support of the claim that the first plant names refer to this level. The work already done by ethnobiologists is limited, for present purposes, by a number of factors: it refers only to biological classes; the claims for natural groupings have tended to be supported only by the ethnographer's mention of a few correlated attributes (a tendency being corrected in Berlin's current ethnobotanical studies--see Berlin, Breedlove, & Raven, 1966); and the location of natural groupings at a particular level of abstraction is defined by linguistic-taxonomic, rather than psychological, criteria (see Berlin, Breedlove, & Raven, 1973).

The purpose of the first experiment in the present research was to provide a systematic empirical study of the co-occurrence of attributes in the most common taxonomies of man-made and biological objects in our own culture.

2. Inseparable from the attributes of objects are the ways in which humans habitually use or interact with those objects. For example, when performing the action of sitting down on a chair, a sequence of body and muscle movements are typically made which are inseparable from the nature of the attributes of chairs--legs, seat, back, etc. For concrete objects which are functioning as concrete, not as symbolic, objects the movements made when using or interacting with the attributes of the object generally delineate the function of the object (for example, the motor movements of sitting on a chair delineate the function of the chair, although the hand motions made with respect to a rectangle of paper are not the function of a negotiable check). It is outside the scope of the present research to consider whether attributes or action sequences are more fundamental; taken at a given point of time, objects in a given culture are manufactured (such as various kinds of chairs) which necessitate highly similar motor patterns in their use, and those motor patterns are employed because the objects are alike in possessing attributes co-ordinate with such patterns. The import of the present argument is simply the claim that humans have consistent motor programs with which virtually all humans interact with virtually all objects of a certain class. Little attention has been previously paid to this motoric aspect of concepts except in Piaget's notion of sensory-motor schemata (Piaget, 1952) and in developmental theories which attempt to include Piaget's concept of sensory-motor schemata (Bruner, Olver, & Greenfield, 1966; Nelson, 1974). The purpose of the methodological part of Experiment 2 of the present study was to develop systematic techniques which could operationalize

and specify in some detail the actual motor programs which adults employ when using or interacting with the most common objects in our environment. The hypothesis was that when motor programs could be measured, basic level objects, the most inclusive classes at which common attributes co-occurred in Experiment 1, would, likewise, be the most inclusive classes at which consistent motor programs were employed for all objects of a class. An additional aspect of this hypothesis (part of the meaning of the claim that the basic level is the most inclusive level at which attributes and motor sequences co-occur) is that classes subordinate to the basic level are characterized by essentially the same attributes and motor programs as are the basic level.

3. Another aspect of the meaning of a class of objects which is inseparable from the attributes and motoric uses of the objects is the general way the objects of the class "look." This is, perhaps, the most difficult of all characteristics of objects to define. There are already in existence three common approaches to defining the closely related problem of object (or pattern) recognition which did not appear to be useful for testing the hypotheses of the present study: (a) The look of an object can be defined as the summation of the look of each of its attributes or parts. This approach, for most purposes, simply leads to an infinite regress (Neisser 1967) which provides no more information than the original question. (b) various (primarily computer based) systems have been devised to define the look of an object as a feature list where features consist of such molecular properties as lines, angles, and curves. While such systems have achieved reasonable success for clearly bounded sets of stimuli such as the letters of the Roman alphabet (Lindsay & Norman, 1972; Neisser, 1967), to attempt such an analysis for the total

set of concrete objects named in Table 1 appeared to be a research project quite other than that which we were attempting. (c) Attempts have also been made in computer modeling to define the recognizable look of an object as a wholistic template. However, at present, such systems can make recognition possible only under the most restricted and unrealistic circumstances (Lindsay & Norman, 1972).

That very important and much neglected aspect of the overall look of objects which proved feasible to use in the present study was the shape of the objects. Shape, it should be noted, is not simply another attribute of objects (like legs, red, makes music, etc.) which we arbitrarily decided to use for further investigation; rather, it is a very general aspect of objects. Included within what we call shape is the structural relationships of the parts of an object to each other--for example, the visual representation of the legs, seat, and back of a chair and of the way in which those parts of the chair are placed in relation to one another. Thereby, shape is probably also the generally most salient visual cue in normal recognition of objects.

In a classic paper, Attneave and Arnoult (1956) discussed the problems of defining and measuring the shape of natural forms. Although this paper has served to initiate much interesting research on universes of complex, rule-based, computer generated forms (Brown & Owen, 1967), the problem of measurement of natural shapes has been essentially ignored. A pilot study for the present research demonstrated that objects were quite recognizable from only the outline tracing of a two-dimensional representation, and were, in fact, as recognizable from such outlines as they were from lists of criterial attributes or from full color views of parts of the objects.

In order to measure similarity of shape, two outlines, normalized for size and orientation, were juxtaposed and the ratio of overlapped to non-overlapped area was computed. The experimental hypothesis was that the same basic level of abstraction identified by correlations of attributes and by sequences of motor movements in the first two experiments would be the level at which the greatest proportional gain in ratio of overlap from the next higher level of abstraction would occur and that gains in amount of overlap would be significantly less for the next lower (subordinate) level of classification. In short, the hypothesis was that, using an objective measure of similarity of shape, the basic level is the most inclusive level at which the objects of a class begin to look very much alike.

4. If the basic level is the most inclusive level at which shapes of objects of a class are similar, a possible result of such similarity may be that the basic level is also the most inclusive level at which an average shape of an object can be recognized. Such a result would be particularly important because, if that is the case, the basic level may be the most inclusive level at which it is possible to form a mental image which is isomorphic to an averaged member of the class and, thus, the most abstract level at which it is possible to have a relatively concrete image. In performing this final experiment of Part I, average shapes were produced for objects at each level of abstraction and subjects were asked to identify both the category and specific objects represented. The hypothesis was that the basic level is the most general level at which either category or object can be identified and that averages of

objects from classes subordinate to the basic are not more identifiable than the basic.

It should be noted that, in a sense, the present research approaches the problem of understanding levels of abstraction in the opposite manner from that used in Berlin's (1972) research in ethnobotany. Berlin defines generic level categories (the proposed basic level for plants) by means of linguistic and taxonomic criteria. Generic classes of plants are those classes named with a primary (usually unanalyzable) lexeme (such as oak) whose subdivisions, if any, are named by secondary lexemes (such as white oak) and whose superordinate, if there is one, is a primary lexeme which names a major life form (such as tree). Generic classes are more numerous than any other classes and are "the basic building blocks of all folk taxonomies" (Berlin, Breedlove, & Raven, 1973, p. 216). Berlin et al (1973) predict that generic classes defined by taxonomic and linguistic criteria will prove to be the most salient classes psychologically. The present research, on the other hand, begins with hypotheses concerning environmental structure and psychological factors and only later preceeds to a consideration of linguistic variables (Experiments 10, 11, and 12). The present approach is intended to be complementary to the linguistic-taxonomic approach taken by ethnobiologists.

As already stated, attributes, use, look, and imageability of objects are integral aspects of the same conception of objects. Analysis of the structure of objects in taxonomies could begin at any of these points, and, in fact, each could well be argued the true starting point by differing fields of psychology. The present order of presentation was chosen largely so that it might begin with a treatment of objects traditional in psychology and linguistics--that is, with lists of attributes.

Experiment 1: Attributes

Experiment 1 actually consisted of three parts. The major source of data was obtained by subjects' listing of the attributes they attributed to object names which had been derived from nine systematically chosen taxonomies. In a second, subsidiary experiment, a separate group of subjects judged the truth (actual characteristicness) of the attributes which had been most frequently listed in the first part of the experiment. In a third, subsidiary experiment, subjects listed attributes of actual visually present objects as a further check on the nature and validity of the attribute lists obtained from the free listing technique employed in the first part of the experiment.

Methods

Attribute Listing

Subjects. Subjects were 200 students in undergraduate psychology courses who volunteered to perform the experiment for course credit.

Stimuli. The stimuli used in the experiment (90 object names belonging to three levels of abstraction in nine taxonomies) are shown in Table 1. These stimuli were chosen systematically according to

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Insert Table 1 about here

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two principles. Since the study was an attempt to investigate the categorization of real-world material objects, the stimuli should represent the most common classifications of concrete objects in our culture. And since all of the hypotheses concerned levels of abstraction in classification of objects, specific stimuli had to be those for which relationships of class inclusion, superordination, and subordination both existed as potentials in the English language and were reliably agreed upon by normal speakers of English.

A measure of the most common superordinate categories of concrete objects was obtained in the following manner: the population of categories of concrete nouns in common use in English was determined by drawing all concrete nouns with a word frequency of 10 or greater from the Kucera and Francis (1967) sample of written English. A superordinate category was considered in common use if at least four items from the category appeared in that list. Categories were eliminated if: (a) the items bore a part-whole relationship to the only reasonable superordinate (e.g. parts of the body, parts of buildings), (b) if there was linguistic ambiguity amongst possible superordinates (e.g. *animal* is commonly used as a synonym for *mammal*), and (c) if the superordinate cross-cut a large number of other taxonomic structures (e.g. *food*).

By these frequency criteria, however, only one biological category, bird, could be included in the study. Since biological taxonomies were the only ones in which hypotheses concerning basic objects based on independent linguistic evolutionary data existed, it seemed desirable to include more than one biological category. Frequency criteria for biological categories were, therefore, reduced so that a biological category was included if at least one member of the category (or the superordinate noun itself) achieved a Kucera and Francis frequency of 10 or more. A total of 13 superordinate categories met the criteria outlined above: musical instrument, fruit, tool, furniture, clothing, vehicle, vegetable, toy, weapon, bird, tree, fish, and snake.

The second criterion for choosing items was the item's "taxonomic depth" in common English. That is, to test the hypothesis that a basic level of abstraction which has the properties outlined in the introduction can be identified, a class inclusion hierarchy with at least three levels of abstraction is needed: a hypothesized basic level (such as hammer), a hypothesized abstract superordinate (such as tool) and hypothesized subordinates into which the basic level can be further subdivided (such as claw hammer and ball-peen hammer).

In order to determine taxonomic depth in common English for our potential items, the following procedure was followed: all of the 13 hypothesized superordinate categories which had met the frequency criteria were categories which had been included in the Battig and Montague (1969) normative tabulations of the frequencies with which instances were produced in response to the category name. For each of the 13 categories, lists were constructed of each of the items appearing 10 or more times in the Battig and Montague tabulations. It should be noted that the majority of items in the categories of nonbiological objects corresponded to the experimenters' intuitions concerning what constituted basic level objects in that category, and, similarly, the majority of items in the biological categories corresponded to Berlin's (1972) claim that the basic level for biological taxa is at the level of the genus. Five judges were given these lists. The judges were asked, for each item, to give the superordinate (or superordinates if he felt more than one was appropriate) and to list any or all subordinates of the item (i.e. any classifications into which the item could be further subdivided).

The final nine taxonomies used in the experiment were those for which, for a given hypothesized superordinate, there were at least three hypothesized basic level objects which met the following criteria: (a) all five judges agreed unanimously on listing that superordinate as the single superordinate for the item, and (b) for each basic level item, there were at least two subordinate classifications which were listed (i.e. agreed upon) by all five judges. In addition, for biological taxonomies, we checked the official taxonomic legitimacy of listed subordinates before including them. The items which met all of the above criteria are shown in Table 1.

It should be noted that the proposed basic level categories chosen for study by the present methods also fit Berlin's linguistic and taxonomic definitions of generic plant classes (Berlin, 1972; Berlin et al, 1973). The basic objects in Table 1 are named by unanalyzable primary lexemes; their superordinates (with the exception of musical instrument) are also primary lexemes, and the subordinates are all secondary lexemes.

Procedure. The stimuli were divided into sets of nine items each. Each set consisted of items at only one level of abstraction. Thus, there was one set of superordinate items, three sets of basic level items, and six sets of subordinate level items. For the basic level items, there was never more than one item per set which belonged to a given superordinate category, and for the subordinate items each set contained only one item from a given basic level (which entailed also from a given superordinate) category.

Twenty subjects received each set. Subjects were run in groups of from 3 to 18. Each item was printed at the top of a page and the nine pages of items in a set assembled in a different randomized order for each subject. Subjects were given 1 1/2 minutes per item. Instructions were made as nearly identical as possible for the superordinate, basic level, and subordinate sets. Specific instructions for the basic level sets were:

"This is a very simple experiment to find out the characteristics and attributes that people feel are common to and characteristic of different kinds of ordinary everyday objects. For example, for *bicycles* you might think of things they have in common like two wheels, pedals, handlebars, you ride on them, they don't use fuel, etc. For *dogs*, you might think of things they had in common like having four legs, barking, having fur, etc.

There are nine pages following this one. At the top of each is listed the name of one common object. For each page, you'll have a minute and a half to write down all of the attributes of that object that you can think of. But try not to *just* free associate--for example, if bicycles just happen to remind you of your father, *don't* write down father.

One more thing, if you have special expertise or knowledge of the category to which one of the objects belongs (for example, if one is the name of a musical instrument which you play, or you're a bird watcher, or you get the name of a tool and you've worked at carpentry or whatever) write that down after the name of the object.

Okay--you'll have a minute and a half for each page. When I say turn to the next page, read the name of the object and write down the attributes or characteristics you think are characteristic of that object as fast as you can until you're told to turn the page again."

Instructions for the subordinate items varied in that they gave the example *racing bicycle* and *collie dog*. Instructions for the superordinate set gave the example *animal* (but not *vehicle* since that was an actual item used in the study). Subjects were timed and told to turn the page and go to the next item at the end of each 1 1/2 minutes. It should be mentioned that subjects did not complain about the time limit and did not appear unduly rushed; most had raised their heads and appeared to have finished by the time they were told to turn the page.

Item tally. The initial phase of analysis of the data from these attribute lists was a simple tally of all attributes listed for all items at each of the levels of abstraction. Before the tally, attributes were classified as noun attributes (such as *legs*), adjective attributes (such as *hard*), and functions or, for the biological categories, actions (such as *you sit on it* or *it eats*). The only effect of performing this classification prior to the final tally was that *four-legs* or *black keys* were classified as adjective attributes and tallied separately and in addition to the corresponding noun attributes *legs* and *keys*. For each item, only attributes which at least six subjects (roughly 30% of the sample) had listed were counted in the final tabulation.

Attributes reaching the criterion of six or more mentions were combined for noun, adjective and functions-actions for an initial analysis of the difference between levels of abstraction. (It should be noted that our subjects failed to differ in expertise for the different items sufficiently for this variable to be examined.)

Judgments of Attributes

The subjects in the previous part of the experiment had been given sufficient time to list all of the attributes that came to mind for each object; they had neither been given the amount of time necessary nor had they been instructed to perform a careful evaluation of the truth or falsity of each attribute they ascribed to an object name. Although with our cut-off criterion of six or more listings per attribute, the lists of attributes obtained seemed generally quite reasonable, there were a few cases in which we felt that an attribute true of a higher level name had made the tally only for a lower level of abstraction (e.g., makes music had not quite achieved six responses for piano) though it had for grand and upright piano) and also a very few cases in which an attribute clearly false for a category as a whole had achieved the required six responses (e.g., red for the category fruit). We, thus, felt it was necessary to have these attributes processed in a judgement task in which subjects were asked to assume a reflective and critical frame of mind and were given unlimited time to make decisions about whether or not an attribute was true of the object for which it had been listed. Subjects were asked only to judge items which had been introduced somewhere in the taxonomy by six or more of the subjects in the free listing experiment; they were not asked to introduce new items.

Subjects. Subjects were students in a seminar. Seven students completed and returned the judgment form out of interest in the experiment.

Stimuli. Twenty-seven separate forms were rated by each subject. For each basic level item all of the attributes which had received six or more tallies for that basic level item, its superordinate or its subordinates in the free listing part of the experiment were listed,in random order, down the left side of the page. Across the top of the page were written the superordinate category name, the basic level name, and the two subordinate level names.

Procedure. Potential subjects were given packets of all 27 forms. The forms were arranged in a different random order for each subject. Instructions were:

"We need your help in analyzing some data obtained from other students in an experiment whose aim is to determine the attributes of common, everyday objects. The subjects in that experiment were given names of objects and asked to list all the attributes of the object they could think of in 1 1/2 minutes. Naturally, they could not ponder about whether the attributes that came to mind were really characteristic of the objects or not. Different subjects listed attributes for classifications at different levels of abstraction.

On the following pages, you will see a list of attributes on the left hand side of the page and four names of classifications of objects across the top of the page. All of the attributes you see were listed frequently by the subjects in our former experiment for at least one of those classifications at the top of the page.

What we would like you to do is judge whether each of the attributes is or is not really true of each of the categories listed across the top of the page. Before making each decision, stop a moment, think of all of the things included in the classification you are judging, and think about whether the attribute is characteristic of all of them. If you feel the attribute is a real characteristic of that category, put a check in the appropriate box. If you feel that the attribute is not a characteristic of the whole category or if you can't decide, leave the box blank.

You may take these forms home with you and take as much or as little time as you feel you need to make your decisions."

Subjects took the forms home with them; completed forms were collected at the regular seminar meeting the following week.

Attributes of Physically Present Objects

Both the free listing of attributes and the judgment of attributes in the previous parts of this experiment relied on subjects' retrieval of items and of attributes from memory. It was of interest to see whether attribute lists produced by one subject listing the attributes of 20 different actual visually present items of a class would correspond with the lists obtained from 20 subjects listing attributes from memory for a single object name.

Two paid subjects were employed for the task. Stimulus sets consisted of one basic level item from each of the nine taxonomies: guitar, apple, hammer, pants, chair, car, tree, fish, and bird (the use of the supposed superordinates for the biological taxonomies will be explained in the results section). The subjects' task was to find 20 different examples of each of the items listed above and (timing themselves with a stopwatch provided by the experimenter) list as many attributes of each item as possible in 1 1/2 minutes. Subjects were told to start with the objects in their own homes when applicable (such as chair and pants) and then to find the other items in the appropriate places: music stores, supermarkets, hardware stores, clothing stores, furniture stores, the street, and pictures in books. For fish, one subject visited the Steinhart Aquarium at Golden Gate Park, one rated pictures in the Crescent Book series _Color treasury of aquarium fish_ (1972). For birds, both subjects used both _Birds of North America: A guide to field identification_ (1966) and _The golden book of bird stamps_ (1966), each picking 20 different pictures from the books using tables of random numbers. Subjects were given essentially the same instructions concerning listing attributes as had the subjects in the listing to name condition except that they were told not to list functional attributes (which they found themselves simply repeating without further consideration for each instance of the object once they had thought of the attribute).

The prototcols for each subject were tallied separately in the same manner as had been the protocols for the 20 subjects listing attributes for each object name in the initial free listing condition.

Results and Discussion

Table 2 shows the average tallies of number of attributes listed six or more times for each level of abstraction. The left hand

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Insert Table 2 about here

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columns show the tallies obtained directly from the attribute listings in the first part of the experiment. The right hand columns show the judge-amended tallies; in computing these tallies,an attribute was added or subtracted only when all seven judges agreed that it belonged or did not belong at the appropriate level. Appendix 1 lists all of the judge-amended attributes for each of the nine taxonomies.

The basic hypothesis of the study was that the basic level would be the most inclusive level in a taxonomy at which a cluster of attributes, believed to be common to the class named, would be listed. An initial glance at Table 2 shows that the results for the nonbiological and the biological taxonomies appear to be quite different--that is, what we had taken to be the superordinate level for the biological classes showed all the signs of being basic level classes, at least for our subjects. The first test of significance was, therefore, a test of whether results for the biological and nonbiological categories (e.g. the level at which a marked increase in attributes occurred) differed significantly; such a test was necessary before the substantive hypotheses of the study could be tested in an appropriate manner. For each category, the proportion of basic level attributes contributed by the increase in attributes between the hypothesized superordinate and the hypothesized basic level was computed. T tests of the difference in that proportion between the nonbiological and the biological categories were computed separately for the raw and the judge-amended tallies. Both proved significant: raw tallies, t (7) = 3.72, $p < .01$; judge-amended tallies, t (7) = 4.11, $p < .01$. This finding supports the idea that for our subjects, the hypothesized superordinate appeared to be the basic level for the biological taxonomies.

The first prediction from the substantive hypothesis was that the basic level would contain significantly more attributes than the superordinate level. T tests of the difference in number of attributes between superordinate and basic level categories were performed for the nonbiological taxonomies. The tests proved significant: raw tallies, t (5) = 4.75, $p < .01$; judge-amended tallies, t (5) = 10.07, $p < .001$. (This hypothesis could not be tested for the biological taxonomies since we had not obtained attribute lists for levels of classification superordinate to the hypothesized superordinates). The second prediction from the substantive hypothesis was that the subordinate level would not contain significantly more attributes than the basic level. This hypothesis was tested for both the nonbiological and biological taxonomies and was supported in all cases: nonbiological: raw tallies, t (5) = 2.89, ns.; judge-amended tallies, t = 1.77, ns.; biological: raw tallies, t (2) = 2.41, ns.; judge-amended tallies, t (2) = 3.01, ns. Thus, for those categories in which the location of basic level objects was clear, the basic level does appear to be the most inclusive level at which objects have clusters of attributes in common.

One additional analysis of these data is of interest. Table 2 combined the results from noun, adjective, and functional attributes. These results were coded separately, however, and can be subjected to additional analysis. Appendix 1 shows that the majority (7 out of 10) of the total number of attributes listed for the superordinates of the nonbiological taxonomies were functional attributes of a very general nature. The percent of gain in function, noun, and adjective attributes for basic level over superordinate and for subordinate over basic level was tested for significance by the Sign Test. Both nouns and adjectives increased significantly more than functional attributes between the superordinate and basic level. For the subordinate level, however, those few attributes which were added tended to be adjectives rather than nouns. In spite of the small number of attributes of any type added, the Sign Test for greater increase in adjectives over nouns between the basic and subordinate levels was significant, $p < .05$.

All of the foregoing analysis was obtained from attributes listed from subject memory evoked by the category name. The last part of the present experiment was intended to compare lists of attributes of actually present objects with those obtained from the object names, using the techniques described in the Methods section. (Because this part of the experiment was performed after the previous parts had been completed, tree, fish, and bird were treated as basic level objects rather than superordinates.)

The attributes listed by the two subjects were tallied in the same manner as has been described for the previous data. There was only one instance in which agreement between the lists of the two subjects was not complete--that is, exactly the same attributes were and were not listed six or more times by both subjects (with the exception of the attribute door handles which was listed enough times to be counted for car by only one subject).

Results of these tallies were extremely clear-cut. Attributes listed six or more times by 20 subjects responding to one object name and attributes listed by two subjects six or more times to 20 instances of the object were in virtually perfect agreement. For all of the nine categories, every attribute listed in the judge amended tallies shown in Appendix I was also listed by both of the present subjects; not one was omitted (it should be recalled that subjects were specifically instructed not to list functional attributes). Furthermore, almost no additional attributes were listed. The complete list of additions is: guitar (wide or pear shaped body); apple (bumps on bottom); chair (metal); pants (no additions); car (headlights, stickshift, hood, fenders, door handles); hammer (claw head); tree (no additions); fish (colorful); bird (no additions).

In summary: the hypothesis of Experiment 1 was that there is a basic level of abstraction in classifications of common objects which is the most inclusive level at which the objects of a class possess numbers of attributes in common. This hypothesis was supported for attribute listings obtained by three different methods: free listing of attributes for object names, judge-amended tallies of attributes for object names, and free listing of attributes for visually present objects. The one unexpected finding was that, for biological taxonomies, the basic level appeared to be the next higher level in the taxonomy than had been initially proposed by anthropological and linguistic-taxonomic evidence.

Such a disparity raises the issue, which need be raised in any case, of the extent to which these findings represent descriptions of the correlational structure of attributes which are located in the real world versus in the knowledge and viewpoint of the subjects. That listing of attributes for visually present objects replicated the findings when attributes were listed from memory argues that the findings were not an artifact of the way in which object names are stored in memory. However, the degree of expertise of subjects did not vary systematically, and it is not known to what extent that may have affected location of the basic level, particularly for the biological taxonomies. Would, for example, an ichthiologist, whether presented with an actual example of a category or with only a fish name, have been able to list sufficient attributes specific to trout, bass, and salmon that the basic level for fish would have been placed at that level of abstraction? The issue of differential knowledge of correlational structures and the issue of the placement of basic level objects in biological taxonomies will be discussed further in connection with the findings of the other experiments.

Experiment 2: Motor Movements

As with Experiment 1, Experiment 2 consisted of more than one part. The main body of the experiment relied on the protocols produced by subjects asked to describe the body and muscle movements made when they used or interacted with specified objects. The objects were indicated, as in Experiment 1, by their names. In the second, subsidiary, part of the experiment--performed as a check on the validity of the protocols obtained in the first part--naive models performed the main general activity which had been described from the object name with a sample of actual objects (e.g. a model sat down in a chair),and subjects described the actual body and muscle movements which they observed.

The major hypothesis of the study was that basic level objects are the most inclusive categories for which virtually the same sequences of motor movements are made to objects of the class. Testing the hypothesis required: first, obtaining a corpus of subjects' descriptions of the body and muscle movements which they made in interaction with objects, the level of abstraction of the object names being varied systematically as in Experiment 1; second, the development of a reliable coding system for those sets of descriptions of muscle movements; and, third, a tally of the numbers of muscle movements in common for the category terms at the various levels of abstraction.

Methods

Descriptions of Imagined Movements to Object Names

Subjects. Subjects were volunteers from psychology classes who received course credit for participation. A total of 200 subjects who produced usable prototcols were tested. Protocols were not used if the subject was not a native English speaker, did not complete the test (left blank more than one of the nine parts), or clearly and obviously failed to follow instructions (e.g. told stories, made jokes, obscene comments, etc. rather than describing body movements) for all nine of the items.

Stimuli. Stimuli were the same nine taxonomies used in Experiment 1 (which are shown in Table 1), divided into the same sets of nine words as had been used in Experiment 1. Twenty subjects received each set.

Procedures. Just as in Experiment 1, subjects were run in groups of from 2 to 19. Instructions were:

"In this study, we want you to do something different from anything you have probably been asked to do in a psychology experiment before. We are interested in the nature of common, everyday objects. Psychologists and linguists (and maybe even people) usually think of objects as made up of attributes; for example, a bicycle might be considered something with wheels and handlebars, that moves, you ride on it, etc. But there is a whole other aspect to objects, which has been neglected, which we feel may be very important--the whole set of body and muscle movements that you make when you use or interact with those objects. What we will want you to do in this study is help us find out about the actual sequences of muscle movements people make when they use or interact with everyday objects. Here's an example of what I mean. Let's take the bicycle again. One of the major things you do with bicycles is ride them. Now imagine you're riding a bicycle. To help you imagine, let's pantomime some of it. (The experimenter pantomimes riding a bicycle and encourages everyone in the group to do so also). Now think about the different parts of your body and what you're doing with them. For example, your legs--what are you doing with your legs? (The experimenter asks for subject participation,at this.point,and makes sure that four or more specific motor movements are mentioned such as reciprocal bending and straightening of knees, applying pressure, etc.). Now what are you doing with your feet? (The experimenter gets subject participation). How about your arms, are they just hanging there? And your hands? (Gets subject participation--bent elbows, grasping hands, movements of arms in steering, movement of fingers, or feet, in manipulating gears and brakes). What are you doing with your head? (Gets head turns, etc). Your eyes? Your back? Your weight? (The experimenter gets every subject to utter at least one answer to a motor movement of a body part by calling on those who don't answer spontaneously).

There are nine pages following this one. At the top of each is the name of a common object. For each page you'll have three minutes to write down the muscle movements that you make when you use or interact with that object, in as much detail as you can. Don't worry about being exact or worry if you don't have time to say everything you could. And don't worry about whether your muscle movements are special to your use or interaction with the object or are the same for other people.--Though if you have special expertise with the object, for example, if it's the name of a musical instrument that you play, the name of a tool and you've worked as a carpenter, etc., please be sure to write that down after the object name.--In general: don't worry. Just imagine in as much detail as possible the very specific sequence of muscle movements you make when using or interacting with each object and write down those movements as fast as you can."

Subjects were allowed three minutes for each item. The name of each item was printed at the top of a blank page. At the end of the three minutes, subjects were asked to stop, turn the page, and proceed with the next item. With the exception of some of the first subjects tested, each subject who received the same set of nine items received them in a different random order.

Coding of responses. After considerable effort in developing a system for reducing the data, the following method of coding was adopted because it was both reliable (it could be applied by three coders with an inter-rater reliability of .88 or better) and because it yielded similarity scores for units of movement which contained a face valid embodiment of the meaning of hypothesis concerning similarity of movements.

The steps for coding the protocols were as follows: each subject's protocol was first divided into the major activities for which that subject described an interaction with that object. For example, while the activity described for chairs was usually the process of sitting down on one, some subjects also described a muscle movement sequence for picking one up and carrying it, dusting one, and other idiosyncratic ressponses. A finer coding was then applied separately to each major activity described by each subject. At each point in the description, the activity was segmented into the body part involved (head, eyes, neck, torso, arms, legs, knees, feet, hands, fingers, wrist, etc.). Under that body part for that mention of that part, each activity (such as bending, rotating, turning, extending, etc.) described for the part was listed. If the same body part was mentioned again later in the description with the same or a different movement as a later part of the sequence, it was coded again with its new movement. (That movement sequences were empirical facts and not simply analytic implications of the meaning of the name of the major activity was demonstrated by the fact that similarly named activities, such as sitting or looking, received quite different movement lists when applied to different objects--e.g. sitting on a chair versus sitting as part of entering a car; looking at a bird versus looking at a tree. This finding indicates the usefulness of the concept of frames as part of the meaning of verbs, Minsky, 1975).

The rating was done by three raters. Reliabilities (percent of rater agreement) for the coding of nine randomly chosen protocols, each for a different object, three at each of the three levels of abstraction were all .88 or higher.

The body part movement listings so obtained were then tallied for two separate counts. The tally of primary interest was that of the degree of similarity between movements made to objects at the three different levels of abstraction. In order to make such a measurement, the tally procedure to be employed necessarily differed from that used in Experiment 1 in several respects. In the first place, for the motor movements, it was not sufficient for the same movement to have been mentioned for it to be tallied as the same. The same movement was considered to have been included in the protocols of two different subjects only if, for the same basic activity in relation to an object, the same movement of the same body part occurred in the same place in the same sequence of movements. For example, if two different subjects mentioned bending their knees as part of the sitting process and that mention occurred between the actions of approaching and/or turning their back to the chair and the actions of touching their buttocks to and/or releasing their weight onto the chair, the bending of the knees was tallied as two occurrences of the same movement. However, if one subject mentioned bending his knees as part of raising his feet to rest them on a desk after having already put his weight onto the chair, it was coded as a different movement and not tallied with the other two bendings of knees. For motion sequences which, in fact, occur simultaneously (e.g. steering and foot pedal manipulation while driving), sequence requirements for coding movements the same were adjusted to fit that fact.

The tally procedure differed from that in Experiment 1, in the second place, because it was necessary to lower the criterion for counting a movement from six or more responses, to four or more (a minimum of 20%) responses. This was made necessary by a combination of the strictness of our criteria for tallying a movement as the same (described above) and by the great variation in individual protocols due both to inclusions by subjects of idiosyncratic major activities for an object and to individual variation in which body parts and muscle movements were mentioned by individual subjects for the same major activity even when subjects appeared to have the same motor sequence in mind.

The second count of body part movements was based on a far simpler measure. This tally was obtained to measure the degree of specificity of the descriptions at each level of abstraction regardless of the overlap in descriptions. To obtain this measure, the raters simply counted each specific movement rated, regardless of body part, place in the sequence, place in the major activity, or repetition of mention of the same movement by other subjects. This count was designed to examine the question of the specificity of the movements described for the class of objects named independently from the question of the similarity of movements made to objects of that class.

Descriptions of Actual Movements of Naive Models

Subjects were a class of 28 students. Four of the students were chosen at random to be the models. They were asked to wait outside the room while instructions were given to the remainder of the class; thus, they did not know the purpose of the experiment at the time that they performed their actions.

The class was told that previous subjects had been asked to describe the body and muscle movements which they imagined themselves making to objects, but that they would be asked to describe the actual body and muscle movements which the models would make when they interacted with actual objects. In order to give this group the same explanation of what was meant by specific body and muscle movements as had been given the previous subjects, the identical instructions were read to them, including their participation in the pantomimed bicycle riding. In addition, the subjects were told to watch the model carefully and to write down the body and muscle movements he or she had made in interacting with the object in as much detail as possible.

The models were called in, one at a time. Each performed one interaction with an object. The four activities were: sitting down on a chair, eating a small bunch of grapes, putting on a sock, and hammering in a nail. The class was given three minutes following the completion of each modeled action to write down the sequence of movements.

Of the 24 protocols collected, two were eliminated because the subjects were not native English speakers; two were eliminated at random; and the remaining 20 were coded exactly as the protocols for the imagined actions had been.

Results

Table 3 shows tallies of movements in common for the descriptions of imagined movements for the three levels of abstraction. The movements themselves, listed under their appropriate major activity and in their appropriate sequence are shown in Appendix 2. The basic results were extremely similar to those for the attribute listing in Experiment 1. T tests showed that the proportion increase in number of attributes between the hypothesized superordinate and basic level categories differed significantly for the non-biological and the biological categories: t (7) = 4.59, $p < .01$. For the nonbiological taxonomies, significantly more motor movements were given in common for the basic level than for the superordinate, t (5) = 14.19, $p < .001$. (As in Experiment 1, this effect could not be tested for the biological taxonomies alone). T tests also confirmed that the number of motor movements given in common for the subordinate level did not differ significantly from the basic level: nonbiological taxonomies, t (5) = .92, ns.; biolgical taxonomies, t (2) = 1.83, ns.

Insert Table 3 about here

Because each of the motor movements tallied was an individual item in its unique place in a motor sequence, a tally of the movements to subordinate level objects which averaged movements added to and those omitted from the movement sequences tallied for the basic level object did not seem a totally sufficient test of the possible differences between movements described for basic level and for subordinate level objects. The two right-hand columns of Table 3, thus, show, respectively, the mean number of added and the mean number of omitted movements for subordinates in each taxonomy. The significance of the difference between the basic level and the subordinates was tested separately for the case in which only additions to the basic level tallies were counted for the subordinate and for the condition in which only omissions from the basic level tally were counted for the subordinate. None of those t tests reached significance. Thus, even when additions and omissions are not averaged, there is no significant difference between the number of movements described in common for basic level and subordinate level categories of objects. The face validity of these results is apparent from Appendix 2; the movements shown added to or excluded from the tallies of subordinate over basic level objects, in general, appear to be random fluctuations in the few movements which did or did not reach the criterion tally rather than movements specific to the subordinate object named.

The second measure of motor movements was a specificity count which included all movements listed regardless of whether or not they were listed in common. Table 4 shows the means for this tally. As in the count

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Insert Table 4 about here

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of movements in common, t tests showed that the proportion of increase in number of movements between the hypothesized superordinate and basic level categories differed significantly for the nonbiological and the biological taxonomies: $t\ (7) = 5.18$, $p < .01$. For the nonbiological taxonomies, the specificity count was significantly greater for the basic level than for superordinate objects: $t\ (5) = 11.93$, $p < .001$. Far from being more specific than the basic level, the actual means for subordinate level objects for both the nonbiological and biolgical taxonomies were lower, on the general speicificity count, than the means for the basic level objects, a difference which, however, did not reach significance: nonbiological taxonomies, t (5) = 2.41, ns.; biological taxonomies, t (2) = 3.42, ns.

Thus, both for number of movements in common and for total number of movements, the basic hypothesis of the study was supported; superordinate categories have few, if any, motor movements that can be made to the category as a whole and few movements in common. Basic level categories receive descriptions of many specific movements made to all members of the category and many of these movements are described by a sufficient number of different subjects to form a picture of movement sequences made in common to all members of the basic level class of objects. Objects subordinate to the basic level did not differ significantly from the basic level either in the specificity of the descriptions or in the number of common movements made to the object. These results must be amended, of course, to include the fact that (as shown in Tables 3 and 4 and Appendix 2 and as verified by the t tests), just as had been found for the attribute listing in Experiment 1, the supposed superordinate level for the three biological categories showed all the characteristics of the basic level, and the supposed basic level for the biological taxonomies showed the characteristics of subordinates.

The above data on motor movements were obtained from subjects' descriptions of imagined movements with object names as stimuli; the subsidiary experiment obtained the same type of protocols for subjects' descriptions of actual movements. As had been the case for attribute listing, tabulations of these descriptions varied remarkably little from the imagined descriptions.

For three of the four actions performed--eating grapes, putting on a sock, and hammering in a nail--all of the movements obtained in the talley of the imagined action were also obtained from tallies of the protocols of descriptions of observed actions. In each of these cases a small number of additional movements also achieved a frequency of four or greater for the observed actions. The number of added movements was a small percent of the number of identical movements: for eating grapes, 3 added to an original 19; for putting on a sock, 2 added to an original 18; and for hammering in a nail, 3 added to an original 20. Appendix 2 lists the actual additions; as can be seen, they are all finer differentiations or extensions of actions already specified in the original sequence; in no case was there a contradiction to or major addition of a portion of a sequence. For sitting on the chair, there were two omissions as well as three additions to the original sequence of motions. As can be seen from Appendix 2, however, these do not represent major changes in the original sequence.. Thus, there is some evidence that the protocols on which the conclusions are based, though obtained for imagined actions, would not have been different, in any major fashion, were they all to have been obtained for observed actions.

Discussion of Experiments 1 and 2

Both for attributes and for motor movements, the general hypothesis of the study was strongly confirmed. There was a level of abstraction in taxonomies at which a number of attributes in common and consistent motor programs were described by subjects. The most abstract level at which motor programs could be coded was always the same level, in each of the taxonomies, at which significant numbers of attributes were listed in common. The consistency of the results for attributes and motor movements suggest that debates such as whether attributes or functions are the more primary (for example, in the child's learning of categories, Anglin, in press; Nelson, 1973) are based on an artificial distinction; that is, according to the present data, the attributes of an object and its functions (in fact, the actual motions made in using the object) are not unrelated factors but are, rather, different aspects of the same correlational structures for the same objects at the same levels of abstraction.

Two major issues have not been dealt with adequately by the techniques of Experiments 1 and 2 alone: the problem of whether the structure delineated by those experiments is real-world or is based on arbitrary linguistic convention and the related issue of the role of ignorance and expertise in what constitutes a basic category. To shed further light on these issues, the following two experiments were designed to deal with visual aspects of objects; in particular, Experiment 3 was explicitly designed to employ a technique which was not dependent on the linguistic intuitions and assumptions of subjects.

Experiments 3 and 4: Shapes of Objects

In order to be able to analyze real-world correlational structures by converging methods, it was necessary to find a method for analyzing similarity in the visual aspects of objects which was not dependent upon subjects' descriptions (as Experiments 1 and 2 had been), which was free from effects of the object's name (which would not have been the case for subjects' ratings of similarity), and which went beyong similarity of the analyzable, listable attributes which had already been explored in Experiment 1. For this purpose, outlines of the shape of two-dimensional representations of objects were chosen, a wholistic and integral aspect of natural forms which includes the structural relation of the parts of objects to each other and which may be the most salient visual cue in normal recognition of objects.

The basic hypothesis of Experiments 3 and 4 was that shapes of objects would show the same correlational structure as had attributes and motor movements in the previous experiments. The specific hypothesis of Experiment 3 was that the same basic objects identified in Experiments 1 and 2 would prove to be the most inclusive categories in which the shapes of objects showed a great gain in objective similarity over the next higher level of abstraction. The hypothesis of Experiment 4 was that these same basic level objects would be the most inclusive categories in which shapes are sufficiently similar to render the shape of an average of more than one member of the category identifiable as a category member. Before performing these experiments, however, it appeared necessary to demonstrate that shape was a reasonable aspect of an object to use to represent its identifiable overall look. Thus, several pilot studies intended simply to demonstrate that objects were readily identified from the two-dimensional outlines to be used in the experiments were performed prior to the experiments themselves.

Choice of stimuli

Choice of the pictures of objects to be used in these experiments was an issue of particular importance. It is clear that the hypotheses of both experiments could easily either be confirmed or disconfirmed by a biased choice of the pictures of objects representing each category. It was, thus, necessary to have an essentially random sample of pictures of objects for any category used: however, some of the nine taxonomies used in Experiments 1 and 2 did not lend themselves to such a choice procedure. Thus, on the basis of availability of large numbers of pictures of members of the category, four hypothesized basic level categories from each of four superordinates (a total of 16 basic level categories) were chosen for use in the present study. These categories are shown in Table 5.

Insert Table 5 about here

For each basic level category shown in Table 5, a pool of at least 100 pictures was obtained. More than half of the pictures in each category (and almost all of the animal pictures) were taken from books. The rest were obtained by photographing objects in the environment- vehicles on the streets and items of furniture and clothing in homes and in stores.

An additional sampling problem was presented by the orientation of the objects in the pictures. There are an infinite number of possible projections of a three-dimensional object onto a two-dimensional surface. Rules were, therefore, required for defining and equating the orientations of objects. Fortunately, there is high agreement among subjects concerning the primary (and in many cases, secondary) canonical orientation in which objects are imagined. To obtain normative data, a class of 61 students was asked to list the orientation in which each of the basic level objects listed in Table 5 were imagined. There was high agreement (over 90% of the students) that all of the articles of furniture and two of the articles of clothing (pants and shirts) were imagined primarily in a front view. The other two types of clothing (shoes and socks) were imagined from side as well as front views; however, all subjects agreed that they found imagining shoes and socks from a front view acceptable. For all of the furniture and clothing, front view pictures were, therefore, used. There was high agreement (90%) that all of the vehicles were imagined in a side view. Side views predominated for animals also with some weight given to front views; all subjects whose primary oreintation for an animal was front, however, agreed that imagining the animals from the side was acceptable. Thus, side view pictures were used for the vehicles and animals. Since none of the hypotheses required comparing items between different superordinates, the difference in the side and front oriented categories did not present a problem. (The high agreement on canonical orientation is itself of interest; one may speculate that the canonical imagined orientation represents the most informative perspective in which to view the object by the same definitions of informativeness used in characterizing basic level objects in the present study).

From the pool of 100 or more potential pictures, the four pictures to be used for each category were selected in two stages: in the first (nonrandom) stage, pictures were discarded on the basis of factors which would make them unusable in the study--for example, an object photographed in other than its canonical orientation or the picture of an object interrupted by another object in the foreground. (Interestingly, the majority of pictures did represent the objects in what subjects had agreed was the canonical orientation of their image of that object). No picture was discarded because of the shape of the object. In the second stage, the four pictures to be used were selected from the remaining pool entirely randomly.

This use of random choice of objects at the basic level had an effect on the availability of subordinate classes; not unexpectedly, the particular pictures chosen were not always classifiable as a member of any particular subordinate class. To obtain subordinate classifications, four judges named what kind of a (basic level name) each picture was for all of the 64 pictures. Six of the 16 basic level classes proved divisable into two objects rated as members of one subordinate class and the other two pictures rated as members of another subordinate class. These six basic level classes were: cars (sports car, sedan car); tables (kitchen table, dining room table); chairs (kitchen chair, living room chair), pants (dress pants, levis); shoes (women's shoes, sneakers); and socks (athletic socks, dress socks). Although these were only six out of 16 possible subordinate divisions, these appeared to be naturally occurring subordinates which had come out of a random choice of pictures of basic level objects and, as such, appeared to be of greater validity for testing the hypothesis than nonrandomly chosen subordinates for each basic level classification would have been.

Once the pictures were selected, it was necessary to normalize size and, when needed, to adjust orientation within the picture plane. This normalization took place in two stages. In the first stage orientation was adjusted and size was approximately normalized photographically. That is, the objects in the photographs were enlarged, reduced and/or rotated to an approximately standard size and orientation by photographic means. At this stage, size was equated only in the sense that the pictures were reduced to the same order of magnitude; all now occupied a 8.89 cm X 12.70 cm framed space. The outlines of the 64 normalized pictured objects were then traced. These outline shapes were the raw material for the stimuli in the pilot studies and in Experiment 3 and 4. Examples of these outlines are shown in Figure 1 in which one of the four objects in each basic level category is reproduced.

Insert Figure 1 about here

In Figure 1, the size of the outlines is reduced to approximately 1/8 the original size. (To compute the ratio of overlapped areas in Experiment 3, the areas of the shapes were equated more precisely by computer).

Pilot Demonstration Experiments

The purpose of the pilot studies was simply to demonstrate that the outline of the two dimensional shape of an object is an aspect of the overall look of an object which it was reasonable to use in the succeeding experiments. The demonstration had two parts: the purpose of the first was to show that objects could be readily identified from their outlines, and the purpose of the second to show that they could be just as readily identified from their outlines as from other, more traditional, sources of partial information about objects such as lists of attributes and views of part of the object. Subjects in all three of the demonstrations described below were volunteers from students in introductory psychology classes who received course credit for participation.

To test identification of objects from their outlines alone, xeroxes were made of the outline tracings of the 64 pictures; the xeroxes were made into individual sets in which each subject received the 64 outlines in a different random order. Subjects were told that these were outlines of pictures of common everyday objects and were asked to write down what they thought the object was for each picture. Twelve subjects participated. In this, and in the two subsequent demonstrations, identifications were considered correct if subjects used the basic level name or any subordinate or synonym of that basic level name. Out of the 64 pictures, the mean number of outlines which subjects correctly identified was 59.8, an average of better than 90%.

The second part of the demonstration consisted of comparison of this rate of correct identifications with that achieved when subjects were provided with lists of the attributes of an object and asked to guess its identity from its attributes. The objects to be guessed were the 27 basic level objects used in Experiments 1 and 2 of Part I of the present study, and the lists of attributes were those attributes which had been listed six or more times by subjects and verified as true of the objects by the judges in Experiment 1. Each subject received, in a different random order, the attributes of all 27 basic level objects with the question "What is it?______" following the list. Sixteen subjects participated. The mean number correct per subject was 25.4, as in identification from the outlines, a mean of slightly over 90% correct.

The third part of the demonstration compared these rates of correct identifications with identifications of objects when only half of each original picture was visible. The original color prints of the 64 pictures whose outlines had been used in the first part of the demonstration were laid around the outer edge of a rectangular table in random order. Half the pictures, randomly chosen, had the top and half the bottom half obscured by a white card. Two groups of subjects, one of 12 and one of 15 participated. Subjects in each group formed a line around the table and simply wrote down their guess as to the identity of the pictured object as rapidly as they could as the line moved around the table. For the second group of subjects, the pictures having their top and bottom halves obscured were reversed. The mean number of correct identifications was 60.3 from top halves only and 55.6 from bottom halves only; an average of slightly under 90% correct.

This entire study was performed as a demonstration only to show that recognition of the identity of an object from the outline of the outer edge of its two dimensional representation was both quite good (approximately 90% correct) and was of the same order of magnitude as recognition of the identity of an object frrom other sources of partial information such as lists of attributes or halves of the entire picture. With the findings of these demonstrations in mind, it appeared not unreasonable to use such outlines as the stimuli in the formal comparisons of similarity of shape to be described in the following experiments.

Experiment 3

The hypothesis of this experiment, in its most general form, was that basic level objects are the most inclusive categories at which the objects in a category "look alike." For the reasons given in the introduction, it appeared necessary to develop an objective measure of similarity of the overall look of the objects rather than to rely on subjects' ratings of similarity, the measure usually used to test such hypotheses (Shepard, Romney, & Nerlove, 1972).

That two dimensional shapes of objects are a reasonable aspect of their overall look to be used in such an objective measure was argued by the results of the pilot demonstrations. The objective measure of the similarity of such shapes which we used was the degree of overlap of the areas covered when two shapes were juxtaposed, a measure which could be used because size and orientation of the shapes had already been normalized (as described under Choice of Stimuli). Thus, the specific hypothesis of the experiment was that the ratio of overlapped to non-overlapped areas would increase by a large and significant amount between superordinate and basic level categories and would increase far less between basic level and subordinate categories.

Methods

Stimuli

The categories used are shown in Table 1. The raionale for choice of these categories and the methods for selection of the four pictures to represent each basic level category and for division of six of the basic level categories into subordinates have already been described.

Procedures

To compute the ratios of overlaps of the normalized shapes, tracings of the shapes were projected by an overhead projector onto an IBM 2250 display scope which was connected to a Meta 4 emulating an IBM 1130 computer. Tracings of the two pictures to be compared were overlapped, orientation remaining constant.

Computation of the overlap may be thought of in Venn Diagram terminology. Two juxtaposed shapes, A and B, have an area in common, AB, and areas not in common, A minus AB and B minus AB. For present purposes, it was necessary to compute the ratio of AB to [(A minus AB) plus (B minus AB)]. To do this, the area covered by each shape was first traced with a magnetic pen onto the projections on the display scope. A program was employed which computed the ratio of the second to the first shape and adjusted the area of the second shape by the percent necessary to equalize it to the area of the first shape. Following this normalization of area, the area covered by either shape and the area covered by both shapes were traced. The second phase of the program computed the desired ratio of overlap.

Because it was impossible, on a practical basis, to compute ratios for all possible combinations of the 64 pictures taken 4 at a time, the following procedure for choosing combinations was employed: one of the four basic level object pictures chosen at random from each of the 16 groups of basic level object pictures was compared with each of the other three basic level object pictures in its group. This procedure produced a total of three comparisons within each basic level group of pictures. The mean of those three ratios was taken as a measure of the average overlap within that basic level category. The same randomly chosen picture that had been compared with the other three pictures within a basic level group was also used as the comparison picture with one randomly chosen member of each of the other three basic level groups within the superordinate. The mean of those three comparisons was considered a measure of the ratio of overlap for that basic level group with other members of its superordinate category. For example, if shirt 2 were chosen to represent shirts, it was compared with shirts 1, 3, and 4, and was then compared with one randomly chosen member of each of the other basic level items of clothing--i.e. with one randomly chosen shoe, one sock, and one pair of pants. The means of the first three and second three comparisons were taken as the data points from which to compare the ratio of overlap among shirts with the ratio of overlap between shirts and other clothing.

For comparison of the within subordinate overlap ratios with the within basic level overlap ratios a very similar procedure was followed. Each of the four items in a basic level group containing two subordinates was compared with each of the others, and each item was compared with one randomly chosen item from each of the other basic groups within its superordinate. From these comparisons, 27 mean overlap scores, three for each of the subordinate item pairs, were obtained. The three scores to be compared for each of the six items were: (a) the mean ratio of overlap between the two pairs of subordinate items, (b) the mean ratio of overlap between each of those same items with the other two items, not of the same subordinate, within the same basic level group, and (c) the mean overlap of those same two items with each of the items in the same superordinate class.

Results

The results were quite clear cut and according to prediction. Of the 16 pairs of comparisons between the mean overlap ratios of items within the same basic level category with items within the same superordinate category, 15 were in the direction within-basic-level ratios greater than within-superordinate-level ratios. The one reversal in sign was the smallest difference of the 16. Such results are highly significant by the Wilcoxon Matched-Pairs Signed-Ranks test, $p < .001$. Of the six comparisons of subordinate with basic level overlaps, five showed greater overlap within subordinate categories than within basic level (a difference which reached significance by the t-test: $t\ (5) = 2.91$, $p < .05$); however, in all six cases, the difference between increase in overlap gained by comparing subordinates with each other over comparing basic level objects with each other was far less than the increase in overlap gained by comparing members of the same superordinate with each other: Wilcoxon, $p < .05$; $t\ (5) = 7.31$, $p < .001$.

In summary: the basic hypothesis was fully supported. A large and consistent increase in similarity of the overall look of objects (as measured by increase in the ratio of area of overlap to nonoverlap of normalized shapes of the objects) was obtained for basic level over superordinate categories; whereas, a significant but significantly smaller increase in similarity was obtained for subordinate over basic level categories.

Experiment 4

Experiment 3 showed that, out of a randomly selected sample of pictures, basic level objects were considerably more alike in shape than objects classifiable under the same superordinate but different basic level names, and that there was less gain in similarity of shape among subordinate objects. The purpose of Experiment 4 was to explore one of the possible cognitive effects of those objective qualities of similarity in shape. The hypothesis of Experiment 4 was that the basic level is the most general level at which an averaged shape of an object is identifiable as that object. Such a finding is of particular interest because it would mean that the basic level was, thus, the most general level at which it is possible to form a mental image isomorphic to the shape of the actual object.

Experimental confirmation of the hypothesis required two results. In the first place, it was necessary to show that averages of objects which cross the basic level but belong to the same superordinate category are not identifiable as members of the superordinate category--that is, it was necessary to show that there is not a shape of an average furniture which can be identified as such. This hypothesis could be proved wrong if it was possible for subjects to identify an average furniture, vehicle, etc. shape as such, by category, better than chance, even when the individual basic level items which had gone into producing the average were not identifiable. The second result required to prove the hypothesis was that averaged basic level items be readily identifiable as such; that is, that the average of shapes of two items from the same basic level category can be identified as to basic level or supordinate category membership. The final hypothesis was that averaged shapes of subordinate items would not show the dramatic gain in identifiability over basic level averages that the basic level averaged shapes were predicted to have shown over superordinate averages.

Methods

Subjects

Subjects were 40 students in undergraduate psychology courses who volunteered to participate in the study for course credit.

Stimuli

To construct the averages, the two outlines to be averaged were overlapped in the appropriate orientation as described in Experiment 3 For all points in which the lines of the two outlines did not coincide, the point central between the two lines was taken and the points connected into continuous line segments.

These average drawings were constructed out of the same overlaps of pictures as were used for computing the ratios of overlap in Experiment with the following exceptions: the randomly chosen exemplar of each of the four basic level groups was combined with two rather than all three of the other basic level members of that group and with two rather than three members of different basic level groups belonging to the same superordinate, the one member to be eliminated in each case was chosen randomly. We, thus, obtained 32 average drawings consisting of averages of objects within the same basic level category and 32 average drawings consisting of averages of two objects from different basic level but the same superordinate categories. Within the set of within-basic-level averages, six items were averages of objects within the same subordinate category and six were averages of one of those subordinates combined with the object from the other subordinate class within the basic level category.

The averages were traced, xeroxed and turned into packets which could be handed out individually.. Each picture was given a code number so that it could be identified for analysis.

Procedures

Twenty subjects received the averages of the superordinate categories and 20 different subjects the averages of the basic level (which included the subordinate) categories. Instructions for the basic level set were:

"On the following pages are outlines of common everday objects. They are tracings of actual photographs. Many of them, however, are average outlines of more than one picture.

On the following pages, you are asked to perform two tasks: (a) Circle the category to which you think the object belongs. (b) Write in your best guess about what the object is after the name of the category which you have circled. If you really don't know, just guess wildly, but write in some name of an object that you think is pictured.

Important: the set of pictures that you have were chosen randomly from a much larger set. So don't feel that an equal number of pictures should belong to each of the categories listed below the pictures. In fact, for your set, many of the categories may not apply to any of the pictures at all. Just think about the drawings, what you think they are, and the category to which you think they belong. Don't worry about distributing your answers over the categories listed below them."

Categories to be circled were listed on each page under the drawing and were the four possible categories plus four others to which no objects belonged. The category choices for superordinate were: animal, building(s), clothing, furniture, part of a human body, plant, tool, and vehicle.

Instructions for the superordinate set were the same with the exception that subjects were told that the pictures consisted of averages of two different objects and that after they had circled the category to which they believed the object belonged, they were to write in guessed names of the two objects of which the outline they were seeing might have been constructed. For both the basic level and superordinate averages, each set consisted of a different random order of the 32 outlines.

Results and Discussion

The first hypothesis concerned the identifiability of average shapes of superordinate objects. It is not inconceivable that there are visual features which make categories such as furniture in general, clothing, animals, etc. identifiable as such and which could be part of an abstract visual representation of superordinate categories. The mean number of correct identifications of superordinate categories per subject was 11, an average close to 1/8 correct. Since only 1/8 would have been expected by chance, subjects could clearly identify the category from superordinate averages better than chance. However, our averages consisted of averages of two outlines and some of the objects remained identifiable at the basic level even when combined with objects of a different basic level category. If superordinate categories are to be shown identifiable as such, identification should be superior to chance even in those cases when neither of the basic level objects which composed the average was identifiable from the average. To test this, each subject's actual number of correct superordinate category choices made without correct guess of a basic level object was compared with the number of choices of such pairs he could have made correctly by chance--1/8 the number of items for which that subject did not correctly guess a basic level object. A Wilcoxon Matched-Pairs Signed-Ranks test of the difference between these two figures for the 20 subjects was not significant. Thus, it can be concluded that, given the conditions of this experiment, subjects' identifications of the superordinate category membership of averaged shapes was not superior to chance when the shapes composing the average were of different basic level objects and when neither basic level object was itself identifiable. From this experiment there is no evidence for visual features which make superordinate categories identifiable as such.

The second hypothesis was that identifications of basic level averages would be better than chance and far superior to superordinate averages. The mean number correct for the basic level was: for superordinate category identification, 27 (a number so far greater than the 4 expected by chance that it need not be analyzed), and for the correct basic level name 25, an amount in the order of magnitude of only 10% less than the 90% accuracy achieved for the unaveraged outline drawings in the pilot study. For all 32 stimuli, for both superordinate categories correct and basic level name correct, every basic level average shape was guessed correctly more times than its matched superordinate average shape, a result highly significant by any means of analysis.

The third hypothesis concerned basic level versus subordinate classifications. Since both types of items were included within the same set, the same subjects classified both types. The mean correct items per subject were: for superordinate category identification--within subordinate 5.1, across subordinate 5.2; for basic level name identification--within subordinate 5.1, across subordinate 4.9. For neither type of identification was the Wilcoxon Matched-Pairs Signed-Ranks test significant. Thus, although in Experiment 3, within subordinate shapes were somewhat more similar (obtained greater ratios of overlap) than cross-subordinates shapes, in the present experiment subjects gave no evidence that they could identify subordinate level averaged shapes better than basic level averaged shapes as such.

In summary, the hypotheses of the present study were clearly supported. Averages of superordinate objects could not be identified as such better than chance; basic level objects were the most inclusive categories at which objects were readily identified. Furthermore, subordinate object averages were no more identifiable than were the basic level averages. These results do not show that humans do form images; however, they do show that basic level objects are the most general level at which a concrete image could be formed which could correspond to an average member of the class.

Conclusions to Part I

The four experiments of Part I of the present study were designed to explore some of the interrelated aspects which make up the correlational structure of objects: clusters of co-occurring attributes common to the class, sequences of motor movements (entire motor programs) common to typical use or interaction with the object, objective similarity in the look of the object (measured by ratio of overlap in shape, normalized for size and orientation); and high identifiability of averages of shapes of objects of the class. These four aspects of basic objects provide converging operational definitions of basic objects. The objective nature of the correlational structures under study is indicated by the fact that for all of the taxonomies studied, regardless of whether language dependent variables such as lists of attributes or language independent variables such as overlaps of shape were used, there was a level of abstraction at which all of these factors co-occurred and below which further subdivisions added little information.

The focus of Part I was, in one sense, an ecological issue--the four experiments were designed to explore the nature of objects and to demonstrate the existence of basic level classifications at which maximum information and maximum validity of cues can be obtained. Psychological processes were only of indirect concern in these experiments. Basic objects, however, have a number of direct implications for psychological processes. The purpose of Part II was to explore some of those implications. After these implications are more fully understood, we can return to a discussion of some of the unresolved issues arising from the converging operational definitions of basic objects of Part I--questions of the extent to which basic objects mirror real world structure and the extent to which ignorance and expertise can alter what constitutes a basic level category.

PART II: SOME IMPLICATIONS OF BASIC LEVEL OBJECTS

The four experiments of Part I were intended to define aspects of the meaning of basic objects. The experiments of Part II are designed to explore some of the implications of basic objects for the nature of cognitive representations, the development of categorization, and for language use and evolution.

With respect to cognitive representations, we tested two hypotheses about basic objects: that basic object categories are the most inclusive categories which can be represented by a code concrete enough to be called an image and that basic object categories are the first categorizations made during perception of the environment, that is, that objects are generally first seen or recognized as members of their basic category. Regarding former, Experiment 4, by demonstrating basic objects to be the most inclusive categories for which it was possible to recognize an averaged shape of members of the class, raised the possibility that basic objects are the most inclusive class at which it is possible to have a representation which is isomorphic to the physical appearance of objects of the class--in short, to have an image of the class. In Experiment 5, more direct proof of the nature of the representation was sought; the specific hypothesis was that the basic level was the most general level of abstraction in which prior presentation of the name of the category could aid perception of an object in a signal detection paradigm. Experiment 6 was designed to provide a convergent demonstration of the hypothesis using the priming paradigm in a same-different matching task (Beller, 1971; Rosch, in press c, in press e). Regarding object recognition, in Experiment 7, subjects were asked to indicate whether pictures of objects were correctly or falsely designated by names presented immediately prior to the pictures. If objects are first recognized as members of their basic categories, such decisions should be made more rapidly to basic object names than to superordinate or subordinate category names.

With respect to the development of classifications, if basic objects are (as defined in Part I) the classes most definable by means of visual perception and by sensory motor interaction with the object, they should be the first divisions of the world learned as categories by the young child. One developmental implication is that basic objects should be the first classes to be sorted in an adult taxonomic fashion by children and should be sorted taxonomically long before the superordinate combinations generally used in such tasks. This hypothesis was tested in Experiments 8 and 9.

Language is closely related to basic level objects; indeed, Berlin (see Berlin, et al, 1973), employing a strategy the reverse of that of the present research for the study of botanical nomenclature in cross-cultural contexts, used linguistic and taxonomic-linguistic criteria to define the generic level (the proposed basic categories in plant taxonomies) for which behavioral data were subsequently sought. In the context of the present research, if basic categories have all of the properties exemplified by the previous experiments, basic objects should be the level of abstraction at which it is generally most useful to refer to objects. Thus, basic object names should be the lexical items normally chosen to refer to any given concrete objects (which was tested in Experiment 10), and names for basic objects should be the first concrete nouns acquired by children (tested in Experiment 11). Finally, on a more speculative level, if basic categories are the level of abstraction at which it is generally most useful to refer to objects, one would expect, in the evolution of languages, that names would evolve first for basic level objects, spreading both upwards and downwards as taxonomies increased in depth. A limited version of this hypothesis was tested in Experiment 12 for speakers of the American Sign Language of the Deaf.

Experiment 5: Signal Detection

Experiment 4 showed the basic level to be the most inclusive level of abstraction at which the averaged shape of different objects in a category could be recognized. Such a finding makes possible a link between the descriptive characteristics of basic objects explored in Part I of the present research and the possible nature of cognitive representations of categories. The basic level of abstraction appears to be the most inclusive level at which objects are sufficiently visually similar that it is possible to have a mental representation of the category which is isomorphic to the physical appearance of the objects. Such a representation may be called an image. Demonstration that the basic level is the most general class which can be coded as an image is particularly important since an image may be a particularly economical code for a category.

Previous work on the effects of imagery on perception has shown that imagery reduces the detectability of incoming signals under conditions in-which the signals are quite different from the image (Segal, 1971; Segal & Fusella, 1970), but that imagery can improve detection of signals when the image is of the thing to be detected (Peterson & Graham, 1974). Specifically, Peterson and Graham found that subjects were more accurate in detecting pictures embedded in visual noise when they were told the designation of the picture prior to presentation than when they were not given advance information. Since Peterson and Graham showed the subjects the unmasked pictures immediately prior to the detection task, the study provided no information about the nature of the representation which subjects might generate solely from hearing the name of an object.

With respect to the present theory, the hypothesis is that basic objects are the most inclusive categories at which it is possible to have an image of the category isomorphic to the physical appearance of the objects. Thus, basic objects should be the most abstract categories for which advance information in the form of the name of the category can aid in a detection task. That is, hearing the basic level name of an object may aid in the detection of a picture of an object of that class even when subjects have not previously seen that particular picture. Superordinate names should not contain enough specific visual information to aid in detection and subordinate names should not be much more effective than basic level names.

Method

Subjects

Subjects were 80 students in psychology classes; 71 participated as part of their section work; 9 were volunteers who received cource credit for participation.

Stimuli

In order to perform this and subsequent experiments, a set of pictures of all of the objects in the nine taxonomies shown in Table 1 was obtained.

Pictures used in the present experiment were pictures for which there was complete agreement by subjects concerning the subordinate, basic, and superordinate names. Because there was ambiguity concerning the level of basic objects in the three biological taxonomies and because subjects from our student population were generally unable to identify items from the biological taxonomies below the level of tree or fish (see Experiment 10), only the nonbiological taxonomies were used in the present experiment.

A total of 18 pictures were used, one for each of the three objects in the six nonbiological superordinate taxonomies. The subordinate level names for these pictures were: livingroom chair, floor lamp, kitchen table; four-door sedan, city bus, tractor-trailer truck; double knit pants, knee socks, dress shirt; claw hammer, cross-cutting handsaw, regular screwdriver; delicious apple, cling peach, green seedless grapes; folk guitar, grand piano, and bass drum.

The pictures were 6.35 X 8.89 cm color photographs. They were mounted on 12.70 X 20.32 cm white cards. Because a two alternative forced choice procedure was used, each picture was mounted randomly on the right or left side of the card. An equal number of pictures were mounted on the right and on the left sides. On the side opposite the picture on each card, a 6.35 X 8.89 cm colored abstract was mounted. These were chosen to provide some approximation to the colors and densely patterned areas of the target picture with which they were paired.

Procedure

Each card was displayed for a 200 msec interval in a two-field Harvard type tachistoscope. The cards were viewed through a mask consisting of intersecting random colored shapes. Between trials, subjects were instructed to fixate a cross which appeared in the center of a 12.70 X 20.32 cm white field. The subject's task was to determine on which side of the card the picture of the object appeared. Subjects pressed a telegraph key with their right hand if they thought the object was on the right, and a telegraph key with their left hand if they thought it on the left. They were told in advance that the target picture would appear equally often on the right and left.

There were four groups of 20 subjects. Subjects in the first group were told only that a picture of a common object would appear on one side or the other; the second group was given the superordinate name prior to each trial; the third group was given the basic level name prior to each trial; the fourth group was given the subordinate name prior to each trial. Subjects were told in advance that each picture would be of a different object and that no picture would be repeated.

The mask and viewing interval had been adjusted by pretesting so that a hit rate of approximately 70% would be achieved in the base condition in which no advance information was supplied. Subjects were given one practice card and one run through the 18 experimental cards. Since subjects had no advance information about the set from which the pictures were drawn (and since, in fact, there are an infinite number of possible pictures of objects which could be named by the subordinate, basic, or superordinate name), the fact that there were three pictures from each superordinate category could not have been expected to affect performance either adversely or favorably in the superordinate name condition.

Subjects were tested individually; testing time was less than 10 minutes per subject. The dependent variable measured was percent correct.

Results and Discussion

The two alternative forced choice format and the fact that the study was not an attempt to measure the detectability of these stimuli per se, eliminated the need to compute d' and B (Green & Swets, 1974) and made possible the use of the simple statistic percent correct to compare differences in detectability between conditions. Mean percents correct for the four conditions were: No information, 71; superordinate name, 69; basic level name, 90; subordinate name, 88. The significance of these differences was tested by a two-way ANOVA (Condition X Category). Since category as well as subjects was a random variable, a Pseudo F(computed by the conservative minimum method, Clark, 1973) was used. The effect of condition was significant: min F' (3, 102) = 5.36, $p < .01$. A Tukey test of differences between the means showed that both the basic level and subordinate name conditions were significantly different from the no-cue and superordinate name conditions but that the former two and latter two conditions did not differ significantly from each other.

The hypothesis of the experiment was confirmed. Basic level categories appeared to be the most abstract level at which the category name supplied subjects with information sufficiently concrete and visual that it could aid them in detecting a picture of a member of the category in visual noise. Superordinate names did not improve detection over the level achieved when no information was supplied. Subordinate names aided detection no more than basic level names.

Experiment 6: Priming

The finding of Experiment 4 that the basic level was the most abstract level at which averaged shapes of objects could be identified and the finding of Experiment 5 that the basic level was the most abstract level at which cuing with the category name could aid detection of the object in visual noise both indicate that basic objects are the most abstract categories at which it is possible to generate a mental representation of the category at the level of concrete visual features. The purpose of Experiment 6 was to obtain convergent evidence for such an assertion using a different experimental paradigm, that of priming.

The technique of priming (Beller, 1971) in a matching task (Posner & Mitchell, 1967) has been used to study the nature of mental representations generated by names for letters (Beller, 1971), colors (Rosch, in press e), and superordinate semantic categories (Rosch, in press c). In a matching task, the subject is instructed to respond same or different to pairs of items; instructions may be to define same as belonging to the same category (in such a case both AA and Aa are same) or to define same as physical identity (in this case only AA would be considered same). If priming is used, on half the trials the subject is informed of the name of the items in advance of presentation of the stimulus pair; on the other half of the trials, the subject is presented the items preceded only by a warning signal. The dependent variable is the effect of priming; that is, the dependent variable is the difference between primed and unprimed responses to the same pair of items. Priming should be expected to affect matching responses, if from the category name, subjects can generate expectations (information, representations, images) about the ensuing stimulus at the level of abstraction needed for the type of judgment required. Matching at the level of category membership would appear to require preparing for and analyzing stimuli at the level of meaning; matching at the level of physical identity, however, would appear to require preparing for stimuli and perceiving the stimuli at the level of physical features.

Rosch (in press c) found that priming selectively influenced responses to pairs of items which were members of superordinate semantic categories when instructions were to define same as belonging to the same category but that priming had no effect at all in this task when instructions were to define same as physical identity. In an analogous task using color names, however, priming affected responses both under same-category and physical-identity instructions. A reasonable interpretation of the different findings for color names and superordinate category names in light of the present research is that from a color name, but not from a superordinate category name, subjects can generate a representation (or image) sufficiently isomorphic to the physical stimulus that it can aid responses under physical identity instructions. Superordinate categories appear to include such visually diverse items that there can be no representation isomorphic to the physical features of the category as a whole. (In fact, subjects who claim to be able to image a superordinate category like furniture, invariably report doing so by imaging a particular item such as a chair or by imaging a symbol such as three blue triangles). The hypothesis of the present experiment is that basic objects are the most inclusive categories for which subjects can form a representation isomorphic to the class at the level of concrete visual features. Basic objects are, thus, the most abstract class at which advance presentation of the category name should be able to affect responses in a same-different matching task under physical identity instructions. Subordinate category names are also expected to affect responses under these conditions but not to affect them significantly more than the basic names.

Two sub-experiments were performed to test this hypothesis; in one, the conditions of Rosch (in press c) were replicated with the change that the basic names of items, rather than the superordinate category names, were used for priming. In the second experimental test, the pictures used in Experiment 5 (which could be named at all three levels of abstraction) were used as stimuli; separate groups of subjects were primed with the superordinate, the basic level, and the subordinate category name.

Methods

Subjects

A total of 65 subjects were tested; all were students in psychology classes who received course credit for their participation. Twenty were tested with the Rosch (in press c) stimuli, 45 with the pictures used in Experiment 5.

Stimuli

Line drawings. The stimuli for the Rosch (in press c) replication were simple line drawings taken from elementary reading instruction materials. These tended to be sufficiently general representations of the basic category that they could not be further categorized at the subordinate level (e.g. an apple could not be identified as any particular type of apple). Each picture was of one typical and one atypical member of each of five superordinate categories. These were: furniture (chair, rug), vehicle (car, sled), fruit (apple, watermelon), vegetable (carrots, onions), tool (saw, hatchet). All were actual pictures that had been used in Rosch (in press c). Pictures were mounted in pairs, centered, on 12.70 X 20.32 cm white cards. The two pictures were spaced .635 cm apart and, on the average, the pair subtended a visual angle of 7° under the viewing conditions in the experiment. Both members of all pairs could be perceived without eye movements.

Each picture occurred once in a physically identical pair (the same picture repeated) and once paired with a different picture. Thus, there were 10 same pairs and 10 different pairs; each occurred once primed and once unprimed, a total of 20 pairs of stimuli.

Color photographs. Pictures were the three items from six superordinate categories used in Experiment 5. The pictures were mounted, adjacent, centered on 12.70 X 20.32 cm white cards. The pair of pictures subtended a visual angle of 10.5°. The _same_ pairs were identical prints of the same photograph. Each pictured object was presented once in a same pair and once paired with a different picture. There were, thus, 18 same pairs and 18 different pairs; each occurred once primed and once unprimed, a total of 36 pairs of stimuli.

Procedure

For the line drawings, 10 subjects served in the condition in which priming was with the superordinate category name, 10 in the condition in which priming was with the basic name. For the color photographs, 15 subjects were primed with the superordinate name, 15 with the basic name, and 15 with the subordinate name.

For both types of stimulus, pairs were presented in a two-field, Harvard type tachistoscope. Each pair occurred twice, once preceded by (primed by) the superordinate semantic category name 2 sec. in advance of the pair, once preceded by the word _blank_ (to perform the function of a warning signal, part of the function of a prime, see Posner & Boies, 1971). An interval of 2 sec. occurred between the prime or the warning signal and presentation of the stimulus, the basic interval used by Beller (1971) and Rosch (in press c, in press d). Primed and unprimed trials alternated, the procedure used in all previous priming research. The category name or _blank_ was spoken by the experimenter who initiated the 2 sec. interval as he terminated the word. During the period preceding presentation of the stimulus, the subject was asked to fixate a cross which occurred in the center of a white 12.70 cm X 20.32 cm white field.

Subjects were told to press the _same_ key only when the members of a pair were physically identical and to press the _different key to all other pairs._ Subjects used their dominant hand for the _same_ key. They were told to respond as rapidly as possible without error. It was emphasized to subjects that they would not be "fooled" by small difference between stimuli, that different pairs would be obviously different objects and that, if a pair appeared identical at first glance, it was identical.

A practice session preceded the beginning of testing. Practice items were drawn from the same categories but were not items used in the test sets. Practice sets contained 10 stimuli for the line drawings, 18 for the color pictures. The practice session familiarized subjects with the nature of the stimuli, the judgment required of them, and the mechanics of the apparatus and of making the response. Subjects received feedback on correctness and response time during practice.

For the test trials, each subject received, in random order (a different random order for each subject), all pairs, primed and unprimed, from all categories, a total of 20 items for the line drawings, 36 items for the color pictures. A test session lasted 1/2 to 1 hour.

Results

Analyses were performed separately for reaction time and for errors for the line drawings and the color photographs. Within each, analyses were also performed separately for same and different responses and separately for groupes primed with superordinate, basic level, and subordinate names.

The line drawings were analyzed by three-way ANOVAs for the variables Primed-unprimed (a within-subject fixed effect) X Good-bad example of the superordinate category (a within-subject fixed effect) X Category (a random variable). Because category as well as subjects was treated as a random variable, pseudo Fs (Clark, 1973) were computed.

Error rates were low (a mean of 3%) and, as in previous studies (Rosch in press c, in press e), did not differ significantly for any of the conditions. For reaction time, the first hypothesis was that there would be no effect of priming for the superordinate category conditions. As was found in Rosch (in press c), in the present study there were also no significant effects of priming with the superordinate name either for the same or the different responses. The main hypothesis was that for same responses, priming with the basic level name would facilitate responses. The analysis showed that a significant effect of priming for same responses primed with the basic level name was obtained: $F'(1, 6) = 6.20$, $p < .05$. Whether the item was a good or poor example of the superordinate category did not produce a significant effect in the present experiment. This variable was not expected to affect responses under physical identity match instructions when primes were the basic level names; a picture of a watermelon may not be the most prototypical exemplar of a _fruit_ even though it may be a perfectly good representation of a _watermelon_. None of the effects for the different stimuli reached significance. Thus, the basic hypothesis for the line drawing stimuli was confirmed; responses of _same_, when _same_ was defined to mean physical identity, were unaffected by priming with the superordinate category name but were significantly facilitated by advance presentation of the basic level name.

The design for analysis of the groups who received the color photographs was a two-way ANOVA (Primed-unprimed X Category) performed separately for the same and different responses and separately for the groups primed with each level of category name. Because category as well as subjects was a random variable, as in the case of the line drawings, pseudo Fs were computed. The overall error rate was 4%. As in the case of the line drawings, none of the effects for error rate reached significance. For reaction time, for the same responses, as predicted there was no significant priming effect for the group primed with the superordinate category name. For the group primed with the basic level name, however, the effect of priming was significant:

$F'(1, 9) = 6.83$, $p < .05$. One of the major advantages of the set of color photographs over the line drawings was that it was possible to name each at the subordinate as well as at the basic and superordinate level. The effect of priming with the subordinate name was significant: $F'(1, 8) = 5.59$, $p < .05$. In order to test whether the effects of priming with the basic level and subordinate name differed significantly, a three-way ANOVA was performed in which the variable Basic name-subordinate name (a between-subject fixed effect) was combined with the variables already tested. The effect for basic versus subordinate name was not significant. None of the effects for different responses reached significance. Thus, for the color photographs, the basic hypothesis was again confirmed. Advance priming with basic object names significantly speeded subjects' responses to physically identical pairs of pictures of the object; priming with the superordinate category name was ineffective under instructions defining same as physical identity. Subordinate names speeded responses as did basic names but were no more effective than the basic names.

Discussion of Experiments 5 and 6

The purpose of Experiments 5 and 6 was to bring together two lines of research: analysis of the properties of categories at different levels of abstraction (performed in Part I of the present paper) and analysis of the nature of the cognitive representation generated by the category name (Rosch, in press c, in press e). From the stimulus properties of categories, it was predicted that basic level categories should be the most abstract categories for which physical features isomorphic to members of the category in general could be part of the cognitive representation of a category.

This basic hypothesis was confirmed by both experiments: Experiment 5 showed the basic level name of an object to be the most abstract name which could aid detection of a picture of the object in noise; Experiment 6 showed basic level names to be the most abstract category names which affected same responses under physical identity instructions. In both experimental paradigms, subordinate names were no more effective than the basic level names to which they were subordinate. These findings are important to the theory of categorization in that they suggest the means by which the economy of information in basic level categories may be represented in economical cognitive codes. The finding also indicates the way in which the theory of levels of abstraction in categorization articulates with arguments that categories are coded in cognition in terms of prototypes. Both implications will be pursued further in the General Discussion.

Experiment 7: Object Recognition

The preceding experiments have all had a design in which a dependent variable of relevance to categorization was defined and, subsequently, evidence was presented that basic objects were the most inclusive categories characterized by that variable. This was the case whether the dependent variable was one which concerned structural bases of categorization, such as attributes common to members of a class, or one which concerned the mental representation of the category, such as category imageability. In terms of the principles of categorization formulated in the introduction, basic objects should, thus, be the categories of greatest cue validity and, thereby, those which are actually most basic in cognition.

The hypothesis of the present experiment was that basic objects are the first categorizations made in perception of the environment. That is, objects are first seen or recognized as members of their basic category and, only with the aid of additional processing, can they be identified as members of their superordinate or subordinate category. Introspective support for this hypothesis comes from Hunn's (note 2) interviews with experienced bird watchers; such individuals (for whom the basic level for birds is, presumably, at the generic level rather than at the level of *bird* as was the case for our subjects--see the *General Discussion*) reported that they recognized a class such as *gulls* directly from seeing the creature; whereas, to identify subdivisions of gull, they consciously looked for and evaluated the distinguishing features. We may speculate that after identification of the basic class of an object, superordinates are derived by inference from the class membership of the basic object and that subordinates are derived from observation of attributes, additional to those needed to perceive the basic object, which are relevant to subordinate distinctions--however, the present experiment was not designed to test these speculations.

If objects are normally first identified as members of their basic category, subjects should be able to verify category membership in basic categories more rapidly than membership in superordinate or subordinate categories. In the present experiment, subjects were presented with photographs of objects--those used in the previous two experiments which could be identified at all three levels of abstraction--and were asked to verify whether or not each was a picture of an X, where X was either a basic level, superodinate, or subordinate name.

This is the first experiment of the present study in which a prediction was made that subordinate classifications would elicit poorer performance, rather than simply performance not significantly superior to, basic level categories. The present experiment is, thus, the first demonstration, independent of theory, that basic objects have greater cognitive primacy than subordinate as well as superordinate classifications.

Method

Subjects

Subjects were 45 students in introductory psychology; 38 participated in the experiment as a demonstration which was part of their class-section work. The additional 7 were volunteers who received course credit for participation.

Stimuli and procedure

Stimuli were the same color photographs as had been used in the two previous experiments. Pictures were mounted in the center of 12.70 X 20.32 cm white cards and displayed in a two-field Harvard type tachistoscope. Subjects were told that they would hear the name of a kind of object and immediately thereafter would see a picture. The subject was instructed to press a response key with the forefinger of his dominant hand if the picture was an object of the type named, and to press another key with his nondominant hand if the picture was not an object of that type. The object name was presented 500 msec before the picture was displayed. This time interval enabled the subject to hear and understand the name (Rosch, in press c) prior to presentation of the picture so that differences in surface characteristics of the word--such as word length or frequency--could not be said to influence the results.

Each of the 18 pictures was presented twice per run, once preceded by a correct name and once preceded by a false name. Pictures and true or false names were presented in a different random order to each subject. Subjects were instructed to respond as rapidly as possible without errors. The complete set of names and pictures were presented for three consecutive runs to each subject. The first two runs were considered practice; reaction time was measured from the third run.

One group of 15 subjects heard the superordinate name and verified superordinate category membership; a second group of 15 subjects verified basic level category membership; and a third group of 15 subjects verified subordinate category membership. All of the false names were taken from different superordinate categories than that to which the object belonged. Thus, for the picture of a chair, the false superordinate name might be fruit, the false basic level name apple, and the false subordinate delicious apple.

Results and Discussion

Table 6 shows the mean reaction time for verification of category membership for the three types of category name. A two-way ANOVA--Type

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Insert Table 6 about here

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of category name (a between-subject fixed effect) X Category (a random variable) were performed on the reaction time data. Because category, as well as subjects, was a random variable, the data were analyzed by means of pseudo Fs (Clark, 1973). True pairs and false pairs were analyzed separately.

The results of the analysis confirmed that there was a significant difference between response times for the three different types of category name. For true pairs: F' (2, 8) = 9.71, $\underline{p} < .01$. A Tukey test showed that basic level category names were faster than either superordinate or subordinate names and that superordinate category names were faster than subordinate. For false pairs: F' (2, 6) = 6.35, $\underline{p} < .05$. A Tukey test showed that basic level names were faster than either superordinate or subordinate names; however, for the false pairs, superordinates and subordinates did not differ significantly from each other. Error rate was low (2%) and did not differ signifcantly by condition.

The basic hypothesis of the experiment was that objects could be identified more rapidly as members of their basic level category than as members either of their superordinate or subordinate category. The results clearly support that hypothesis. The nature of the additional processing required for superordinate and subordinate identifications cannot be established from the present experiment; that the process is not identical for superordinate and subordinate identifications is indicated by the significant difference between responses to those types of name for the true pairs.

As in British empiricist philosophy, present accounts of perception and imagery tend to assume that a percept based on sense data (and the image corresponding to it) must occur at the most concrete and specific level of abstraction (see, for example, Höffding, 1955). Experiments 5 and 6 indicated that images can occur for and are as effective for basic level as for subordinate categories. The results of the present experiment suggest that the first and primary unit of identification for objects is the basic level, rather than the more specific subordinate, category. Further evidence for the primacy of basic level over subordinate categories will be presented in the experiments on language. Such results indicate that the level of abstraction at which indentification occurs may be determined by information processing considerations of the type discussed in the introduction to the present article.

Experiments 8 and 9: Development of Categories

There is a long tradition of sorting research in the developmental literature which indicates that young children and adults classify objects in different manners. Adults, when given instructions to "put together the things that go together" tend to put things together taxonomically (e.g. objects that belong to the same category); whereas, the younger the child, the more likely he is to sort on the basis of complexive groupings--associations, stories, chains, and other non-taxonomic criteria (see, for example, Annett, 1959; Bruner et al, 1966; Denny, 1974; Garrettson, 1971; Goldman & Levine, 1963; Thompson, 1941; Vygotsky, 1962). The stimuli used in sorting tasks have tended to be of two types: (a) If abstract stimuli (e.g. geometric forms varying in dimensions such as form, color, and size), they are typically presented in a set which has no structure (e.g. each attribute occurs with all combinations of all others), or (b) If representational stimuli (e.g. toy versions or pictures of real world objects), the arrays are typically such that they can be grouped taxonomically only at the superordinate level; thus, the representational stimuli in sorting tasks are such that if the child were to sort the objects into those of like taxonomic category, he would have to put together such items as socks and shirt, or dog and cow. We could locate no previous studies in which children were given an opportunity to sort together objects belonging to the same basic level category (e.g. several shoes or several dogs). Perhaps this is related to the fact that basic objects are so obviously the "same object" to adults (see Experiment 10) that a task does not seem to be a categorization problem to an adult experimenter unless objects are taken from different basic level categories.

The development of classification skills is a complex topic. The nature of the task appears to make a great difference; for example, even children as young as 2 yr. appear to possess some working knowledge of superordinate categories if recall of categorically related versus unrelated items is the dependent variable (Goldberg, Myers, & Perlmutter, 1974). And there can be no doubt that some aspects of the logic of categorization develop with age (for example, Bruner et al, 1966; Inhelder & Piaget, 1956; Vygotsky, 1962). However, in light of the present theory of categorization, the nature of the stimulus array is also predicted to make a great difference. In terms of cue validity, basic objects are those that are the most differentiable and, thus, the generally most useful distinctions to make in the world. With respect to sensory-motor development, basic objects should be the first categories learned by means of visual perception and sensory motor interaction with the object. With respect to imageability, basic objects are the most inclusive categories for which an image can be formed; if children encode the world by images or other iconic representations before they encode more symbolically (as argued, for example, by Bruner et al, 1966), basic objects should be learned easily by children on this ground also. In short, early development of basic object categories appears to be greatly overdetermined.

The purpose of the following two experiments was to replicate the design of previous sorting studies in which only superordinate classifications had been possible using stimulus materials which enabled subjects to make basic level classifications as well. The hypothesis was that sorting into basic level categories is a very primitive response which is not dependent upon the development of mature adult naming or reasoning. It was, thus, expected that basic level sorting would occur at the earliest ages and would be independent of superordinate sorting or of a child's ability to explain his categories.

In the following experiments, subjects at each of the following ages--3 yr., 4 yr., kindergarten, grades 1, 3, and 5, and adult--were divided into two groups, one of which was given an opportunity to sort sets of color pictures of common objects such as animals, vehicles, clothing, and furniture into groups of basic level objects, the other of which was given the same pictures but in sets cross-cutting the basic level so that taxonomic sorting would necessarily be at the usual superordinate level. The 3- and 4-year-olds received only two categories, and the task was administered in the form of oddity problems; the older groups received four categories, and the standard sorting task and instructions were used.

Experiment 8

While children below the age of 6 yr. may have difficulty understanding instructions in the standard sorting task (Bruner et al, 1966; Nash, Note 3), oddity problems can be comprehended at much younger ages (Gelman, 1972). Thus, in order to be able to include nursery school age children in the experimental design, the first experiment employed an oddity problem format.

Method

Subjects

Subjects were 40 nursery school children, 40 elementary school children, and 20 adults. The children included 20 3-year-olds, 20 4-year-olds, 10 kindergarteners, 10 first graders, 10 third graders, and 10 fifth graders. In each age group, exactly half of the children were males and half females. Mean ages at the time of testing, for each age group respectively, were: 3 yr. 5 mo.; 4 yr. 7 mo.; 5 yr. 7 mo.; 6 yr. 5 mo.; 8 yr. 8 mo.; and 10 yr. 7 mo. The adult subjects (6 males, 14 females) were undergraduates who participated in the experiment for course credit. Socioeconomic status of the subjects was unknown.

Stimuli

Stimulus materials were color photographs of animals and vehicles. Four categories of animals--cats, dogs, butterflies, and fish--and four categories of vehicles--cars, trains, motorcycles, and airplanes--were used. Pictures were selected from the pool of 100 or more pictures of objects from which the pictures for Experiment 3 were selected. In the present experiment, however, pictures were not eliminated if the objects were shown in a noncanonical orientation. Four pictures were used for each basic level category. Two sets of triads were used: one which could be correctly paired at the basic level, and one which could be correctly paired only at the super-ordinate level.

basic level, and one which could be correctly paired only at the superordinate level.

To prepare the basic-level triad set, four pairs of pictures from each basic level category were made yielding 16 pairs per superordinate. Pictures were paired with the restrictions that each of the four available pictures per basic-level category be used twice and that the two pictures in a pair not be the same color. The third member of the triad was chosen from the other superordinate category by the following procedure: there were four pairs of pictures within each basic level category. Each of the pairs was combined with one picture from each of the four different basic level pairs of the other superordinate. Thus, from the four pairs of cats, one pair was combined with a car, one with a truck, one with a motorcycle, and one with an airplane. The four pairs of fish were combined with a different car, truck, motorcycle, and airplane. This procedure was repeated for all eight categories, yielding 32 different triads.

To prepare the superordinate triad set, each picture from a basic level category was paired with one picture from each of the other basic level categories within the same superordinate. Thus, each car was paired with one train, one motorcycle, and one airplane. Again, the restriction was used that the two pictures in a pair not be the same color. This procedure yielded six sets of four pairs for each superordinate. Each pair was combined with one member from the other superordinate category according to the procedure described for basic level pairs. There were 48 triads in the superordinate set. For both the basic level and superordinate sets, all pictures were used an equal number of times.

Procedure

For the two nursery school groups, triads were presented to the child, one at a time. The three pictures were put on the floor, and the child was told to put together (point to) "the two that are alike, that are the same kind of thing." After the child had gone through the entire set, the last six triads were shown to the child, one at a time. He was reminded which two pictures he had put together and was asked why they belonged together. If the child gave any reason other than a taxonomic one, he was asked if there were any other reason why the two pictures belonged together. Triads were presented in a different random order to each subject, and the order of pictures within triads were shuffled between subjects. Half the subjects in each age group (10 subjects) performed the task with the basic level set and half with the superordinate set. The nursery school children and the adults participated in the entire experiment as outlined above. Because a ceiling in correct sorting of both basic level and superordinate pairs had been reached by age four, and because a ceiling in giving taxonomic reasons for sorts for the basic level had also been reached by age four, the other subjects (elementary school children) were required to sort only six randomly chosen superordinate triads, for which they were asked to give the reason for their sort.

Results and Discussion

The results were quite clear. At all age levels, basic level sorts were virtually perfect; for the 3-year-olds, the percent correct for basic level sorts was 99, and for 4 years and older, basic level sorts were perfect. Performance was considerably lower for the youngest age group, however, on sorts of the triads which could only be paired at the superordinate level. 3-year olds, 55% correct; 4-year olds, 96% correct.

There were no sex differences; data for both sexes were, therefore, combined in the analyses reported. A three-way Analysis of Variance (ANOVA) was performed on the pairing responses for the triads. Between-subject factors were Grade (3-year olds, 4-year olds, and adult) and Type of category (basic or superordinate). Category (animal or vehicle) was nested within Type of category. The dependent variable was percent of correct responses. The effects of primary interest were that of Type of category and the interaction between Type and Grade. The prediction that basic level sorts would be correct significantly more often than superordinate sorts was confirmed, F (1, 54) = 26.58, $p < .01$. Because a ceiling in performance on these simple triads had been reached essentially by age four, a significant interaction could be expected between Type of category and Grade; that result was also obtained, F (2, 54) = 18.54, $p < .01$. These two results show that there do exist objects which even small children will classify in the same manner as adults. Basic level sorts are equally easy for all age groups; it is only superordinate level sorts which improve with age.

Not unexpectedly, the main effect of Grade was also significant: F (2, 54) = 20.9, $p < .01$. The effect of Category (animal or vehicle) was not significant--F (1, 54) = .49, ns.--and no interaction other than that between Type of category and Grade was significant. A Tukey test confirmed that 3-year olds performed significantly worse than either 4-year olds or adults, while there was no difference in performance between the latter two groups.

From the results of the sorting alone, it might be argued that the findings are simply a function of language development; that is, that children learn the names for basic level objects before those for superordinate categories, and that items are put together when the child knows they have the same name. Two pieces of evidence from the present study argue against such an interpretation.

Subjects' reasons for six of their sorts were obtained for all age levels. These reasons were classified into taxonomic reasons (giving the name of the two items placed together) and all other reasons such as giving attributes or autistic responses. To demonstrate the failure of naming to account for sorting results, results for percent of correct names for superordinate sorts are shown in Figure 2. Adults are omitted because they were perfect in both sorting and naming.

Insert Figure 2 about here

Two points are made clear by Figure 2. For all ages, correct sortings were superior to correct namings. (This was true also for the basic level names at the youngest age; correct sorts for 3-year olds were 99%, correct names 65%; however, a ceiling was reached for basic level names by age four). Since a difference between sorting and naming could conceivably have been due partly to guessing (correct sorts could sometimes have been produced by chance but correct names had to be generated from an infinite set of linguistic responses), correct names were compared for the animal and vehicle categories. As already reported, there were no differences in percent of correct sorts between the animals and vehicles; however, as Figure 2 shows, animal pairs were named correctly far more often than vehicles at all age levels except the youngest, in which names for both were poor, and adults, in which names for both were perfect. The significance of this finding was tested by the Sign test (correct responses for animals versus vehicles for each child). Separate analyses were performed for each age level. The difference between animals and vehicles was not significant for the 3-year olds or adults but was significant for all other age levels: 4-year olds, $p < .035$; kindergarten, $p < .004$; grade 1, $p < .004$; grade 3, $p < .016$, grade 5, $p < .016$.

In summary: pictures of objects classifiable into basic level categories were classified in an adult taxonomic manner by children at all ages, including 3-year-old children. Only the sorts of superordinate level objects showed the usual improvement with age. Evidence was presented that these results are not simply due to difference in knowledge of names for basic and superordinate level categories. Thus, the basic hypothesis concerning the effect of stimulus sets on sorting was confirmed.

Experiment 9

Experiment 8 used a simplified oddity problem format in order to create a meaningful task for 3-and 4-year-old children. However, in most previous studies a different sorting procedure has been used. In order to use a task directly comparable to that of previous studies, and in order to have a task difficult enough to show sorting differences for children older than 4 years, a second study was performed which was based on the same logic as Experiment 8, but which used a standard sorting format.

Methods

Subjects

Subjects were 64 children and 16 adults. The children were 16 kindergarteners, 16 first graders, 16 third graders, and 15 fifth graders. In each group, exactly half the children were males and half females. Mean age at the time of test, for each group respectively was: 5 yr. 7 mo.; 6 yr. 5 mo.; 8 y[illegible] 4 mol; and 10 yr. 7 mo. Adult subjects (6 males, 10 females) were undergraduates who participated in the experiment for course credit. Socioeconomic status of the subjects was unknown.

Stimuli

Stimulus materials were color photographs of objects in four categories. Three of the categories were divided into superordinate and basic level classes. These were: clothing--shoes, socks, shirts, pants; furniture--tables, chairs, beds, sofas; vehicles--cars, trains, motorcycles, airplanes. These pictures were from the same pool of pictures used in Experiment 3 and were chosen in the manner described in Experiment 8. In addition, another category, people's faces, was added because of its intrinsic interest and attention attracting qualities to children. This category was subdivided into men, women, young girls, and infants which were included in the sorting set in the manner that superordinate and basic level categories were included. However, there was reason to believe that these pictures belonged to a toxonomy which contained more than one possible basic level (see the General Discussion) and that the tendency to sort peoples' faces together would be as strong as the tendency to sort men's faces, etc., together (Carey, DeVilliers, & DeVilliers, Note 4). The human pictures were intended to provide an impetus to the children to sort both the superordinate and basic level sets taxonomically.

There were four sets of stimuli which could be sorted at the basic level and four sets which could only be sorted taxonomically into superordinate categories. Basic level sets consisted of one of the basic level categories from each of the four superordinates. For example, one subject might receive four shoes, four chairs, four men's faces, and four cars. Two subjects at each age level received each basic level set. To form the superordinate sets, each picture within the basic level sets was numbered arbitrarily 1, 2, 3, or 4. For a set, all of the like numbers were combined. For example, one subject received shoe 1, sock 1, shirt 1, pants 1, table 1, chair 1, car 1, etc. Two subjects at each age level received each superordinate level set.

Procedures

The pictures in a set were shuffled and laid in front of the subject in random order. Instructions were: "Here are some pictures. (The experimenter called the child's attention to each picture by pointing to each in turn). Put together the ones that go together, the ones that are the same kind of thing." The child was encouraged to include all of the pictures in his groupings. If his first sort was not taxonomic, the pictures were returned to a random order and he was asked if he could find another way to put them together. When the child had finished each sort to his satisfaction, he was asked why those pictures went together.

Results and Discussion

A child was considered to have sorted taxonomically if either his first or second sort was broken into four groups of four pictures corresponding to the four categories built into the stimuli. The pattern of results was very similar to that obtained in Experiment 5. As in Experiment 5, there were no sex differences. For the basic level categories, all but one child in kindergarten and all but one child in the first grade sorted in an adult taxonomic fashion. For superordinate level sorts, however, only half of the children in each of those grades sorted taxonomically. All of the children in the older group (grades 3 and 5) and all of the adults sorted taxonomically for both basic level and superordinate sets. Because the results for kindergarten and first grade were identical, those two groups were combined for a $\underline{X}^2$ comparison of the difference between basic level and superordinate sorts. Results confirmed that for this group, basic level sets were sorted taxonomically significantly more than superordinate sets: $\underline{X}^2$ (1) = 3.64, $\underline{p} < .05$. Thus, as had been the case for the oddity problems of Experiment 8, children of all ages were virtually perfect when sorting the basic level stimuli, and only showed the usual developmental trend in sorting the superordinate level categories.

The children's reasons for their sorts were divided into taxonomic and nontaxonomic reasons following the procedures of Experiment 8. The comparison of taxonomic sorts and reasons are shown in Figure 3.

Insert Figure 3 about here

The production of taxonomic reasons lagged behind taxonomic sorting responses. Separate $\underline{X}^2$ tests were performed for grades kindergarten and 1 and for grades 3 and 5 for the difference between the number of children giving taxonomic reasons versus the number giving taxonomic sorts. Both tests were significant: for the younger group, $\underline{X}^2$ (1) = 18.66, $\underline{p} < .001$; for the older group, $\underline{X}^2$ (1) = 3.79, $\underline{p} < .05$. In the present experiment, the probability of correct sorting by chance was extremely small (unlike the 1/3 correct guessing probability for the triads of Experiment 8). Thus, the difference between taxonomic sorts and taxonomic reasons indicates that the sorts were based on principles other than simple knowledge of the category names.

In summary: for a traditional sorting task, as well as for the oddity problems of Experiment 8, it was shown that even kindergarten children sorted in an adult taxonomic manner when given categories which could be sorted at the basic level. Developmental changes in sorting occurred only for sets which could be grouped solely at the superordinate level.

Discussion of Experiments 8 and 9

In two tasks in which children were instructed to put together the things that were alike, went together or were the same kind of thing, sorting into basic level categories was already at ceiling at the earliest ages (age 3 yr. for an oddity problem procedure, kindergarten for a sorting procedure). As expected, basic level sorting was independent of superordinate sorting and independent of the reasons given for the basic level sorts; both superordinate sorting and reasons for sorts developed with age in the manner found in previous sorting studies. Because basic level sorting was already at ceiling at the earliest ages studied, it was not possible to examine sorting of subordinate categories independently; it seems unlikely that sorting of subordinate classes will not be performed earlier than sorting of the basic level classes to which they are subordinate; however, such a demonstration is left to future research.

Because sorting into basic level categories is, by the nature of basic level objects, overdetermined, the present experiments do not distinguish among the possible bases on which children may have performed their sorts. In fact, in light of the present research, it would not appear to be a fruitful approach to ask whether children classify on the basis of form _or_ function _or_ attributes _or_ category names _or_ "similarity" or any other single criterion. A consistent finding of the present research project has been that these factors are not independent. Children are probably engaged in learning the co-occurrence contingencies of their environment and probably categorize on the basis of their knowledge of those contingencies. Experiments 8 and 9 of the present study have been a first step in demonstrating the primacy of basic level categories in development; further specification of the complex processes by which environmental structure (and adult categorizations) become internalized in children requires additional research.

Experiments 10, 11, and 12: Implications for Language

The present theory of categorization has a number of implications for language. The purpose of the following experiments was to make initial explorations of three of those implications. In the first place, if basic objects are the most general classes at which attributes are most predictable, at which objects are used in the same way, at which objects can be readily identified by look and at which objects can be imaged, basic objects should generally be the most useful level of classification to use in the world. That is, in most situations, the distinction for which a lexical item is needed should be a distinction encoded by a basic level name. Thus, object names at the basic level of abstraction should be the names by which objects are most generally designated by adult speakers of the language. Experiment 10 of the present research tested this hypothesis by means of a naming task.

By an analogous argument, if basic level objects are those first learned by visual perception and sensory motor interaction, and, as was demonstrated in Experiments 8 and 9, if basic objects are sorted in a taxonomic fashion even by young children, basic level names should be the first linguistic labels for objects acquired by the child. This hypothesis was tested in Experiment 11 by use of the developmental linguistic protocol's of Roger Brown's Sarah (Brown, 1974).

In the third place, all of the structural properties of basic objects indicate that they should be the classifications of concrete nouns which it is most necessary for a language to encode. Thus, if a language lacks taxonomic depth in domains of concrete objects, it can be predicted that basic level classes will be present and that it will be superordinates and/or subordinates which are lacking. Because environment and culture are part of what make up the real world co-occurrence of attributes on which basic categories are structured, such a hypothesis would be difficult to test, at present, in a setting greatly different from the environment and culture of speakers of standard English. It proved possible, however, to test the hypothesis in a limited manner by a study of some object taxonomies in American Sign Language of the Deaf, a language spoken by people sharing the same basic material culture with speakers of standard English.

Experiment 10

Method

Subjects

A total of 130 subjects participated in the naming task. The majority (105) were students in psychology classes who performed these brief tasks as part of their classwork. Additional subjects in some conditions were obtained from psychology student volunteers who performed the task for course credit.

Stimuli and procedures

Stimuli were 6.35 X 8.89 cm color pictures of all of the objects in the nine taxonomies shown in Table 1. That is, there was one picture which represented each of the subordinate level names (two per basic level category) listed in the two right hand columns of Table 1.

There were two parts to the experiment. In the first part, subjects named the pictures; in the second part, we verified that individuals from the same subject population did, in fact, know the superordinate and subordinate names.

Instructions for naming were:

"This is a very simple experiment. You have been given a packet of pictures of common objects, each taped to a piece of blank paper. Before you do anything else, I want you to leaf quickly through the entire packet so that you have glanced at all of the pictures. Go ahead...

Now turn back to the first page and go through the packet again Write, under each picture, the name of the object that is pictured. Write down the first name of the object that comes to mind. Don't worry about why you are naming the object what you do. There are no tricks. This is a very simple study. Work as quickly as you can."

Ten copies of each picture were used. The prints, in plastic envelopes, were inserted into the pages of a packet on which subjects wrote the names. Three types of packet were used: those in which one picture from each superordinate category appeared (a total of 9 items per subject); one in which one picture from each basic level category appeared (a total of 27 items per subject); and one in which all pictures appeared (a total of 54 items per subject). These represented three different contrast sets: one in which the superordinate name was sufficient to identify each item from among the others, one in which the supposed basic level name was needed to identify each item, and one in which only the subordinate name would distinguish each item from the others.

A total of 10 subjects named each item; this meant that a total of 60 subjects named items in the superordinate contrast sets, 20 subjects in the basic level contrast sets and 10 subjects in the subordinate contrast set.

Because a tendency to name at the basic level might be attributed to lack of knowledge of superordinate and subordinate terms, the second part of the study investigated subjects' knowledge of these names. For the superordinate names, subjects received all of the 54 items with the statement under each, "This is an X" where X was the correct superordinate name for half of the pictures and an incorrect superordinate name for half of the pictures.

Subjects checked "True," "False," or "Don't know." Ten subjects received each picture with a true, and 10 with a false superordinate name; thus, 20 subjects participated in this condition. Due to the results for the biological categories in the previous experiments of the present research and the results of the naming portion of the present experiment, the superordinates used for the biological categories were plant and animal.

A similar design was attempted for verification of subordinate names, but a tendency of subjects to mark"true" even when questioning revealed they knew the name to be false, required a change to an identification procedure. Pictures of the two subordinates of a basic level category were mounted side by side; underneath was printed the correct subordinate name of one of the pictures, and subjects were asked to check the picture correctly described by that name. The correct name appeared 10 times for each item of the pair. A total of 20 subjects participated. For this condition, the names for items in the biological categories were at the level show as the supposed basic level in Table 1.

Results and Discussion

Results for the naming are shown in Table 7. These results are quite

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Insert Table 7 about here

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unequivocal. Regardless of contrast sets, subjects overwhelmingly used the basic level name in this free naming situation.

There are two possible claims that these results might be artifacts of linguistic facts other than level of classifiction. One claim is related to word frequency. What are here called basic level names can be claimed to be simply more frequent than superordinate or subordinate names, and it can thus be argued that, in this name production task, subjects simply replied with the most available (frequent) word for that object. While word frequencies are not obtainable for the subordinate classes (except in the case of the biological taxonomies where psychological subordinates have monolexemic names), word frequencies were available (and the location of the basic level was unequivocal) for superordinate and basic level names in five taxonomies. In 9 of the 15 cases of superordinate-basic level comparison, the superordinate name actually had a higher word frequency than the basic level name; however, in these cases subjects showed no greater tendency to name with the superordinate than in the cases where the basic level name was more frequent--in both situations, as shown in Table 7, the tendency to name with the superordinate was virtually nonexistent.

The second factor other than level of classification to which the naming results might be attributed was subjects' linguistic ignorance; it could be argued that subjects might simply be ignorant of the correct superordinate or subordinate name. The second part of the study was addressed to that possibility. Results were as follows: for superordinate names, there were no errors at all in any of the true-false judgments. For the subordinate level identifications, for the nonbiological categories, 16 of the 18 pairs (32 subordinates out of 36) received errorless identification. (The two pairs on which errors were made were cling and freestone peach and folk and classical guitar). For the biological categories, there was confusion concerning all of the fish and concerning the oak and maple trees. The three birds were distinguished with no errors. Thus, the overwhelming use of the basic level name can not be attributed to ignorance of correct designations for items at other levels of abstraction.

In summary: the hypothesis was that the basic level name of an object would be the term most used for the object in a free naming situation. For 54 objects from nine taxonomies, there was virtually total agreement in the use of names at the same level of abstraction as had been verified as the basic level in previous experiments. These results were not an artifact of word frequency or lack of knowledge of names at other levels of abstraction.

Experiment 11

The second implication of basic objects for language which wasexamined was the hypothesis that names at the basic level of abstraction should be the first acquired concrete nouns in the language development of a child. One well documented case was taken for analysis; the protocols for the spontaneous speech of Sarah (Brown, 1974). The corpus of analysis were 2-hr weekly recordings of Sarah's spontaneous speech during her initial period of language acquisition (all of her utterances in Stage I; see Brown, 1974, for definitions of the stages in child language acquisition).

Two raters read Sarah's protocols. All utterances of an item in any of the nine superordinate taxonomies previously studied were recorded. Repetitions of an adult's utterance or of Sarah's own utterance were not included. These utterances were classified as superordinates (the superordinate term itself or any synonym); basic level (any word on the same level of linguistic contrast as the basic level items in Table 1--see Frake, 1969 or Rosch & Mervis, in press, for definitions of linguistic contrast); or as subordinates (any term on the same level of linguistic contrast as the subordinate terms in Table 1).

The results of the study are shown in Table 8. Results were sufficiently

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Insert Table 8 about here

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extreme as to render statistical analysis unnecessary. Both in number of tokens (total number of utterances of any word in a classification) and number of types (number of different words in the classification used), basic level names were essentially the only names used by Sarah in Stage I.

That this was not an artifact of word frequency was readily apparent. More than four times as many basic level terms which had lower frequencies than their superordinate occurred in Sarah's prototcols than basic level names that had higher frequency than the superordinate.

Additional support for the primacy of basic level names in children's acquisition of concrete nouns comes from a study, performed by the second author, of the names given by children for the pictured objects used in Experiment 10. Thirty 3-year-old children were each asked to name nine of those pictures. Of the total of 270 names given, only one instance was not a basic level name. Although not all of the names provided by the children were correct, errors were not words at higher or lower levels of abstraction than the basic; they wre basic level names for different objects than those pictured--for example, the (green seedless) grapes were frequently called blueberries.

In summary: for one intensively recorded case study of language acquisition, it was found that essentially all of the child's first utterances of concrete nouns in the nine most frequent categories of such nouns in English were at the basic level of abstraction. Furthermore, young children, like the adult subjects in Experiment 10, used basic level names almost exclusively to name objects in pictures.

Experiment 12

The third implication of the theory of basic level objects in classification has to do with language function and evolution and is considerably more speculative than the other two implications. The hypothesis is that basic categories are the most necessary in a language. If that is the case, when taxonomic depth is reduced in some domains in a language, it should be basic level objects which will be coded and names for superordinate and/or subordinate categories which will be lacking.

Deaf Americans live in the same environment of concrete objects possessing the same correlational structure as do hearing Americans. However, there appear to be fewer fixed signs for concrete objects in Sign than in spoken language, possibly because of the capability in Sign for other forms of communicative elaboration (see, for example, Klima & Bellugi, in press). Thus, American Sign Language of the Deaf (ASL) appeared to be an ideal case on which to test our hypothesis.

The study was performed by the fifth author, herself a fluent speaker of ASL. Four informants were used: three deaf individuals whose native language was ASL and one hearing linguist fluent in ASL. Informants were interviewed extensively concerning the existence of signs for the items at each of the levels of abstraction in the taxonomies in Table 1. An effort was made to determine those categories for which a consistent sign or sign combination was used (as in the spoken English), and those categories which did not appear to be coded at all in ASL (e.g. were communicated, if at all, by a lengthy explanation or by finger spelling of the English word). In computing the results, a consistent sign or sign combination was considered to exist if any one of the four informants thought it existed.

The results are shown in Table 9. Because there were different numbers

Insert Table 9 about here

of categories at the different levels of abstraction, percents of the possible terms are shown. A one-way ANOVA was performed for the difference between the percent of superordinate, basic level, and subordinate signs for the nonbiological taxonomies. The six nonbiological categories served as the random variable in the analysis. Results were: $F(2, 5) = 16.37$, $\underline{p} < .01$. A Tukey test showed there were a significantly greater percentage of signs at the basic level than at either the superordinate or subordinate, and that there were significantly more signs at the superordinate than at the subordinate levels. Although there were too few biological categories to analyze statistically, it is clear that, as was the case for hearing subjects, the supposed superordinate appears to be the basic level for these taxonomies.

The present experiment confirmed that, in one language which lacks some of the terminology for concrete objects which exists in standard English basic level terms were almost as common as in English, whereas, superordinate and subordinate terms were significantly less common. Thus, this study demonstrates, in a limited way, the primacy of lexical items for basic level categories in language.

In addition, the present study raises a more general issue. Why does standard English need designations for superordinate and subordinate categories for those domains in which ASL does not? Why are classification systems found in language at all? A more detailed analysis of classification and use of language in the deaf community using ASL may provide clues for the more general question. In addition, examination of taxonomies in other languages (when possible in historical depth) might prove extremely enlightening; by study of when taxonomic depth does and does not occur in languages and by study of the evolution and degeneration of taxonomic depth, we may gain a great deal of knowledge of the functions and development of languages.

Discussion of Experiments 10, 11, and 12

The preceding three experiments have demonstrated that the names of categories shown to be at the basic level of abstraction by previous experiments are the names which are most used by adults, which are first used by children, and which appear to be the names most necessary in a language. These three experiments were designed to analyze lexical factors as dependent variables which were predicted from the nonlinguistic concerns explored in earlier experiments. No implication was intended that the existence and use of those lexical items is not itself an important factor in cognition. Naming as such may serve a variety of functions in storing, transforming, and transmitting information both publicly and to oneself. Effects of naming--for example, the possible conservatism in categorization under conditions of environmental change which codification of categories by names may produce--is an interesting topic for speculation and research.

The fundamental point made by the preceding experiments is that language (specifically lexical designations of concrete noun categories) should not be treated as an independent variable which occurs capriciously; rather, language is predictable and makes sense in the context of the nature of categories. It should go without saying that humans will use language for the purposes needed in any situation; if distinctions more general than the basic level are necessary, such larger units will be referred to, and if distinctions finer than the basic level are required, subordinates will be used. The claim, on the basis of all which the present research project has demonstrated about categories, is simply that it is the distinctions made by basic object names which a human, acting in his environment, will most often wish to make. Such a claim has been supported by the three preceding experiments.

GENERAL DISCUSSION OF PARTS I AND II

The basic argument of the study was that categorizations which humans make of the concrete world are not arbitrary but rather highly determined. They are determined, in the first place, because the world, as perceived by human sense organs, is not an unstructured total set (in Garner's, 1974, terms) of equiprobable co-occuring attributes; rather, the material objects of the world can better be represented as subsets possessing high correlational structure. Categories are determined, in the second place, because, in so far as categorization occurs to reduce the infinite differences between stimuli to behaviorally and cognitively useful proportions, the basic category cuts in the world should be those which yield the most information for the least cognitive load; in terms, they should be the most inclusive categories which can follow the correlational structures perceived in the world. By this property, basic objects are the categories at the level of abstraction for which the cue validity of categories is maximized; categories at higher levels of abstraction have lower cue validity than the basic because they have few attributes (broadly defined) in common; categories subordinate to the basic have lower cue validity than the basic because they share most attributes with contrasting subordinate categories.

The four experiments performed in Part I of the study were designed to explore some of the interrelated aspects which make up the correlational structure of objects: clusters of co-occurring attributes common to the class, sequences of muscle movements (entire motor programs) common to typical use or interaction with the object, objective similarity in the look of the object (measured by ratio of overlap in shape, normalized for size and oreintation); and identifiability of an average shape of objects in the class. For all of the taxonomies studied, there was a level of abstraction at which all of these factors co-occurred and below which further subdivisions added little information.

The eight experiments performed in Part II were designed to explore some of the implications of basic objects. The two major implications concerned economy of representations and the general usefulness of categories. By the converging techniques of signal detection and priming, the basic level was shown to be the most abstract level at which a category could be represented by a code which was isomorphic to the appearance of objects in the class; thus, the basic level is the most inclusive level at which it is possible to use that most economical cognitive code for the class--the mental image of the average look of the object. By means of verification of category membership of pictures of objects, evidence was found to support the claim that objects are first seen and recognized as members of their basic category. All of the findings implied that basic level classes should be the easiest and most useful distinctions to make in most situations; findings which have both developmental and linguistic implications. With respect to development, children were shown to sort basic objects taxonomically at ages in which the superordinate sets usually supplied children in sorting experiments are largely sorted by complexive principles. With respect to language, basic object names were shown to be the most used by adults, the first used by children developing language, and the least dispensable in a language possessing fewer lexical items than standard English. In short, all of the varied techniques used to study levels of abstraction in natural categories converged in indicating the same level of abstraction to be the level at which the basic category cuts are made.

The present experiments have been described as exploring the correlational structure of objects. The major issue which these studies raise is the extent to which--and the meaning of and manner in which--structure is "given" by the world versus created by the perceiving organism. Such questions can be discussed on a number of levels.

In the first place, the present research is empirical and not intended to be related to any of the classical issues of philosophy. The claim that there is structure "out there" in the world is not a metaphysical claim about the existence of a world without a perceiver. Rather, it is an empirical claim which includes the perceiver--that is, it is the claim that, given a perceiver who can perceive the (in this example, complex) attributes feathers, fur, and wings, it is an empirical fact "out there" that wings co-occur with feathers more than with fur. What kinds of attributes can be perceived is, of course, species specific. A dog's sense of smell is more highly differentiated than a human's and the structure of the world for a dog surely includes attributes of smell which, as a species, we are incapable of perceiving. Furthermore, since a dog's body is constructed differently from a human's, his motor interactions with objects are necessarily differently structured. The "out there" of a bat, a frog, or a bee is undoubtedly more different still than that of a human.

On the empirical level, given that a human is capable of perceiving some set of attributes, and that those attributes possess a correlational structure in the world, the state of knowledge of the person may differ from the potential provided by the world in that: (a) the person may be ignorant of (or indifferent or inattentive to) the attributes, or he may know of the attributes but be ignorant concerning their correlational structure, and (b) he may know of the attributes and their correlational structure but exaggerate that structure, turning partial into complete correlations (as when attributes true only of many members of a category are thought of as true of all members). What are basic objects for an individual, subculture, or culture must be an interaction between potential structure provided by the world and the state of knowledge of the peoples who are categorizing. However, the environment constrains categorizations in that human knowledge cannot provide correlational structure where there is none at all (except in the special sense of creating new sets of man-made objects); all that humans can do is be ignorant of or exaggerate correlational structures that are potentially there. The possibilities of ignorance and of exaggeration of structure will be discussed in turn.

Ignorance and knowledge of existing structure

What possible ignorance of existing structure means for the interpretation of the findings is that, while the level of abstraction which was found consistently to constitute basic objects for our subjects had the potential to constitute basic objects, this level of abstraction was not necessarily the only potential basic level of objects (i.e. correlational structure) for those taxonomies.

Let us take, as an example, the case of airplanes, a vehicle used in both experiments in Part II and in a classroom demonstration which included the tasks of Part I. While airplane appeared to be the basic level for most of the students participating (i.e. the most inclusive level at which many attributes and motor movements were listed in common, at which an averaged shape was recognizable, and at which the greatest gain in overlap of shape from the next higher level in the taxonomy was obtained), for one former airplane mechanic, the taxonomy appeared to be quite different. The lists of attributes common to airplanes produced by most subjects were paltry compared to the lengthy lists of additional attributes which he could produce in common for different types of airplanes. Furthermore, his motor programs as a mechanic were quite different for the different attributes of the engines of different types of planes. Finally, his visual view of airplanes was not the canonical top and side images of the public (which were the types of pictures of airplanes which had been used for measuring overlaps of shapes and recognizability of averaged shapes); his view concerned the undersides and engines of airplanes, for which quite different locations of the basic level in the shape experiments would obviously have been obtained.

Further interviewing of this one subject (an informant in the anthropological sense) revealed that his differentiation of airplanes was not infinite; he considered a single and twin engine Cessna quite similar, and thought that they would probably constitute subordinates for him. Furthermore, he considered airplanes as a whole more similar to each other than vehicles, and he was able to take the role of an uninformed person and list attributes common to all airplanes, imagine the muscle movements he would make as an entering passenger, and also imagine an average airplane shape from the outside. In short, airplanes appear to be an example of a category in which either one or two sets of correlational structures are available depending upon degree of knowledge of the perceiver. A hypothetical taxonomy of this type and of a potential one-level type are graphed in Figure 4. In this figure,

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Insert Figure 4 about here

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basic level objects are depicted as elbows in graphs of attributes in common, motor movements in common, similarity in shape, etc.

By reference to the two hypothetical taxonomies of Figure 4, we can now clarify the possible reasons for the disparity between our findings in regard to the biological taxonomies and those previously predicted from anthropological and linguistic data (Berlin, 1972). The first possibility is that biological taxonomies are actually of the type in which only one basic level grouping is possible regardless of degree of knowledge and that the earlier anthropological predictions were in error. In support of such a contention is the fact that when one examines the full range of any species (for example, see oak, maple, and birch in The Trees of North America, 1968), one finds that at the species level, biological classes are not discrete bundles of correlated attributes, but, rather, contain many subtypes within species whose characteristics merge with those of other species. For example, attributes of oaks which one might think would differentiate that species distinctively from maples--such as tree shape, leaf shape, and seed type--in fact, overlap maples in all of those characteristics when all varieties of the two species are considered.

Berlin (Note 5) has countered this argument with the observation that folk biological taxonomics are, by definition, created by the inhabitants of a single ecological zone who come into contact with only a few of the varieties of each species. Thus, in folk taxonomies, the species should be a level of abstraction at which potential correlations of attributes exist. That English speakers once made basic level distinctions at the level of the genus is suggested by the number of monolexemic terms for biological genuses available in English (see the bird, fish, and tree names in Battig and Montague, 1969). Such lists of terms are not similarly available for subordinates of chair, shirt, hammer or for any of the other nonbiological basic level terms in our taxonomies. The second possible explanation of the data is, thus, that biological taxonomies are of the type in which two basic level groupings are possible but that our city dwelling subjects were ignorant of the attributes in common, potential movements to be made in interaction with the objects, and the similarities in shape which were characteristic of the generic level biological categories in their environment.

The effects of expertise on classification is an issue for which systematic study is needed. It may be argued for all taxonomies, there is a level below which further differentiations cannot form basic level categories because, no matter how great the frequency of use of the objects or degree of expertise, there simply are not a sufficient number of attributes, movements, etc. which differentiate objects below that level. Thus, for any taxonomy, there should be a level at which the attributes, motor movements, and other information common to objects which is added by further distinction(s) will be outweighed by the attributes which the newly distinguished classes share with each other. When a further distinction reduces, rather than increases, the cue validity of categories at the new level of classification, that distinction can be said to result in subordinate categories rather than new basic level categories. The only way in which it may be argued that distinctions which are basic level classes can be added indefinitely is to redefine the total set whose structure is under consideration to include, at each point, only the narrowest class under consideration. Thus, Phillips-screwdrivers-one-inch-long and Phillips-screwdrivers-1/2-inch-long can be basic level classes if the total set (the universe of discourse) is defined to include only very short Phillips screwdrivers. While this may be a way to characterize the classification system of a specialized machine, it does not seem to be a reasonable way to characterize the cognitive reorganization which takes place in a human mind with increases in expertise. Both theoretical formulation of the change in knowledge structures engendered by gaining expertise and empirical study of experts are needed before this question can be discussed intelligently.

Not only does expertise not appear to be able to differentiate categories indefinitely, but the effect of expertise is probably often confined to specific parts of a taxonomy, thereby, creating unevenness in the expert's categorization of that taxonomy. One can easily imagine a poultry farmer for whom chickens and turkeys (and/or subordinates of these birds) are basic level objects but for whom the rest of the bird class remains undifferentiated, and one can imagine an antique furniture dealer for whom Chippendale and Hepplewait chairs are basic level objects but for whom kitchen and living room chairs, in the average house, are as undifferentiated as they were for our subjects. Indeed, differentiation of mammals (but not birds, fish, and other major divisions of animals) into basic level objects can be observed at the present time in our own culture which is more knowledgeable about mammals than other animal classes. This may, in fact, be the reason behind lack of use of the word *mammal* by English speakers; mammals are thought of as members of their basic level classes and called by their basic names--and such names are one level in the taxonomy lower than are the basic level classes and names for other major animal classifications. Until studied further, the effects of expertise on classification remain largely speculative.

Exaggeration of structure: prototypes

In addition to ignorance of potential structure, any person or culture may exaggerate existing structure; that is, attributes, motor movements, and shapes which are characteristic of only some or most members of a category may be thought of as though they were characteristic of all members. By such a mechanism, the basic category cuts in the world are made to appear even simpler and more structured than they are in reality. Such simplification may occur through the coding of categories in cognition in terms of prototypes of the most characteristic members of the category. Thus, even when correlational structure in the world is only partial or when attributes are continuous, thereby, producing categories which might tend to blend with other categories at the same level of abstraction, categories can be maintained as discrete by their mode of cognitive coding.

It is at this point that an articulation exists between the present research on the taxonomic structure of categories and earlier research on the internal structure of categories and the coding of categories in terms of prototypes (see Rosch,in press d; Rosch & Mervis, in press). There is considerable converging evidence that some natural categories are analog rather than definitively bounded entities (see Lakoff, 1972; Rosch, 1973; Zadeh, 1965) and that some natural analog categories are internally structured in cognition into items which differ in their degree of prototypicality--that is, in the degree to which the items are seen as clear cases or good examples of the category and in the degree to which they fit subjects' "idea or image" of the meaning of the category name (Berlin & Kay, 1969; Heider, 1972; Mervis, Catlin, & Rosch, 1975; Rips, Shoben, & Smith, 1973; Rosch, 1973,1974, 1975, in pressb, in press c, in press d, in press e; Rosch & Mervis, in press; Smith, Rips, & Shoben, 1974).

In attempting to determine the principles by which the internal structure of natural semantic categories is formed, Rosch and Mervis (in press) have shown that the more prototypical of a category a member is rated, the more attributes it has in common with other members of the category and the fewer attributes in common with members of contrasting categories. This finding was demonstrated for natural language superordinate categories, for natural language basic level categories, and for artificial categories in which amount of experience with items could be strictly controlled. Thus, it would appear that prototypes of categories form by the same principles as (the present research has argued) basic categories themselves are formed. Prototypes appear to be just those members of a category which most reflect the redundancy structure of the category as a whole. That is, if categories form to maximize the information-rich clusters of attributes in the environment and, thus, the cue validity of the attributes of categories, prototypes of categories appear to form in such a manner as to maximize such clusters and such cue validity still further within categories.

Such a concept enables us to understand, in greater depth, some of the apparently anomolous data from the present research. In Experiment 1, the attributes listed by subjects and verified as true of the category as a whole by the judges, were not true for every example conceivable of the category (see Appendix I). A reasonable hypothesis is that subjects and judges were thinking of the more prototypical category members when making the judgments, and that those attributes not literally true of all items classifiable as members of a category are true of items rated as more prototypical. Evidence supporting this hypothesis was obtained by Rosch and Mervis (in press); subjects were asked to list attributes for 20 members of varying prototypicality from each of six superordinate categories. As was found in the present research, there were virtually no attributes common to all members of these superordinate categories; however, the five items rated most prototypical within each category tended to have many attributes in common with each other. The same hypothesis can be applied to the motor movement sequences of Experiment 2.

It is through prototypicality that an articulation may be made between the structural principles of categories investigated in Part I of the present study and cognitive coding of categories. In the first place, prototypes would appear to enable a subject to make use of his knowledge of the contingency structure of the environment without his being forced to engage in the laborious cognitive process of continually computing and summing the validities of individual cues. Probability models for the cognitive processing of categories, such as cue validity, and distance models, such as matching to a prototype, have been treated as two fundamentally different forms of categorization model whose conflicting validities must be tested by empirical research (Reed, 1972). However, Rosch and Mervis (in press) showed that empirically defined prototypes (items rated most prototypical) of natural categories were just those items with highest cue validity. Such an internal structure of categories provides the means for maximally efficient processing of categories. If prototypes function cognitively as representatives of the category and if prototypes are items with the highest cue validities, humans can use the efficient processing mechanism of matching to a prototype without sacrificing attention to the validity of cues.

In the second place, prototypes enable humans to make greater use of representational codes such as imagery, a type of code which (whatever its status as a variable, Pylyshyn, 1973), can be argued to be useful or necessary for the performance of many cognitive activities (Paivio, 1971; Cooper & Shepard, 1973). Previous studies have shown that concrete representations of categories (representations which can affect same-different matches under physical identity instructions) are more like prototypical than nonprototypical members of the categories (Rosch, in press e; Rosch, Simpson, & Miller, Note 6). Prototypes of superordinate categories, although they consist of the category members with highest cue validity and, thus, code the attributes most representative of the category, none-the-less, are particular category members which are visually quite different from other members. Basic objects are the most abstract categories for which an image of the prototype can be reasonably representative of the class as a whole (Experiments 4, 5, and 6). Thus, it is through prototypes that the efficiency of basic level categories in providing the most information for the least cognitive effort can be translated into an actual cognitive code.

Just as ignorance and selective expertise about categories created uneveness in the categorizations within a taxonomy, variation in basic level classes and coding of these classes in terms of prototypes of the most typical members undoubtedly creates unevenness in classifications within basic level categories. Objects nominally within a basic level class may be sufficiently divergent from typical members of the class that they may constitute a separate potential, evolving, or, in some sense, actual basic level category. For example, the objects now called *bean bag chairs* in English, may well have attributes, motor movements, and shapes in common with each other and sufficiently different from typical chairs that these items are thought of as a basic level category separate from and on the same level of abstraction as *chair*. The same is very probably the case for atypical members of biological categories; althought for our subjects, *bird*, *fish*, and *tree* were basic level classes, members of these classes such as *penguin*, *lobster*, and *palm tree*, undoubtedly constitute classes differentiated from the basic level categories as a whole. Thus, while a typical looking chair or bird may be perceived and recognized first as a member of the basic level class *chair* or *bird*, a sufficiently deviant member is probably perceived first as a member of its individual class (e.g. *high chair*, *flamingo*). One obvious implication is that, in a task such as that used in Experiment 7, sufficiently deviant items should be verified faster for their "subordinate" name than for the name of the basic level category to which they are allied. Other implications concern the name that will be used in a free naming situation such as that in Experiment 10 and the name first learned by children. In the latter regard, it may be pointed out that Anglin (in press) found that adults used the basic level name bird for a moderately deviant item such as a pigeon when naming the object for a child but the specific name pigeon when naming the object for an adult. Studies are presently in progress to explore such differentiation of basic level categories.

Universality of the principles of categorization

From the beginning of Part I of the present paper, it has been implied that the study concerned universal principles of categorization. But what aspects of the theory are intended to be universals? The content of categories should not be. It has been argued that categories reflect both real world correlational structure and the state of knowledge of that structure of the people doing the categorizing. Since the structure of the environment, both the man-made objects and the flora and fauna of a region, should differ greatly in different parts of the world, one would expect the categories of different cultures to differ. In addition, interest in and knowledge of attributes and their correlation for specific domains can be expected to differ among cultures, subcultures, and individuals.

What is claimed to be universal in the present research are the principles of category formation. On the most general level, the assertion is that categories form so as to be maximally differentiable from each other. This is accomplished by categories which have maximum cue validity--that is, which have the most attributes common to members of the category and the least attributes shared with members of other categories.

For categories of concrete objects, this general principle leads to claims for a number of more specific principles which are asserted to be universal for concrete objects. For this domain, given that there are correlational structures which exist in the environment and which are known of and attended to by a culture and an individual, the present claim is that the basic cuts in the environment are determined. Basic object categories will be the most inclusive categories which mirror the correlational structure of the environment, that is, the most inclusive categories which have many perceived attributes in common, very similar motor movement sequences made to objects of the category, are similar in their overall look, and can be represented by means of a concrete cognitive code. Universally, such categories should be the basic classifications made during perception, the first learned and first named by children and the most codable, most coded, and most necessary in the language of any people.

There are limitations to the generalizability of those claims for universality which are specific to concrete objects. To the extent to which categories are not concrete, the overall look of an object and the motor programs for using it may not be necessary concommitants of the attributes and functions of the object. This is true of concrete objects used abstractly as well as of abstract categories as such. As in the example given previously, the motor movements of sitting on a chair comprise the function of the chair; however, the hand motions made with respect to a rectangle of paper are not the functions of a negotiable check. The separation of shape and motor movements from the attributes of the object are even more obvious for those categories which we call abstract such as causality or democracy. Even for clearly concrete objects, there may be boundary conditions beyond which the universality of the present formulation may not be expected to apply. For example, very small objects which have attributes in common and can be used by means of the same motor programs might not necessarily have the similarities in shape which one would expect of larger objects with common attributes and motor programs.

There are also limitations to the generalizability of claims for a basic level of abstraction which are due to the fact that the present research dealt only with class-inclusion taxonomies. No attempt was made, for example, to examine categories having a part-whole relationship between members or with categories which cross-cut other taxonomies (such as food).

However, the most general principle of categorization, that categories will form which are most differentiable and have maximum cue validity, may be very generally applicable even to abstract categories and to items not in class inclusion relationships to each other. For example, with respect to the structural relationship between parts of a figure, Palmer (1975) has shown that elements of a figure form a distinct part to the extent that the association (measured by the Gestalt principles of grouping) between elements which are members of the part is high and association of those elements with other parts is low. In yet another field of analysis, the segmentation of the stream of happenings (or narrative) into events (or scenes or contexts--see Bobrow & Norman, in press, for a discussion of terminology) may follow principles of categorization similar to those applicable to objects. For example, certain units of segmentation such as washing clothes (Bransford & Johnson, 1973) or going to the movies may be basic units in a sense analogous to basic objects; such segments may have more attributes and/or more internal connectedness of segments within the event and less attributes in common with and/or connectedness to other events than either broader or narrower characterizations of such an event. Finally, these general principles of categorization may prove applicable to organisms other than humans. Given knowledge of the needs, activities, and sensory systems of a species, it might prove possible to predict the basic cuts in the environment made by that species. Note that extension of the principles of categorization beyond concrete objects and beyond humans brings up the basic issues of how to delineate the total set and define the attributes from which structure is composed; such issues await further formalization as the concepts are extended to new fields.

In summary: contingency (correlational) structure is undoubtedly one of the aspects of the environment of greatest importance to all organisms, a point made long ago by Egon Brunswik (1956), but little pursued since. The present theory predicts that the correlational structure of the environment (broadly defined), modified by selective ignorance and exaggeration of the attributes and structure of that environment, will be mirrored in all categorization systems. That is, segmentation of experience, at all levels, will occur so as to maximize the differentiability and, hence, cue validity of categories. Such a hypothesis offers a framework for prediction and comparison of categories across cultures and across domains of discourse. In short, the basic claim is that categorization is not arbitrary but makes sense in any context; the preceding research has offered a programmatic way of looking for the sense.

Summary

The basic argument of the study was that categorizations which humans make of the concrete world are not arbitrary but highly determined. They are determined, in the first place, because the world, as perceived by human sense organs, is not an unstructured set of equiprobable co-occuring attributes; rather, the material objects of the world can better be represented as "subsets" possessing high correlational structure. Categories are determined in the second place, because the world appears to be so structured that in taxonomies of concrete objects there is generally one level of abstraction at which the most basic category cuts can be made. Basic categories are those which carry the most information, possess the highest category cue validity, and are, thus, the most differentiated from one another.

The four experiments reported in Part I defined basic objects by demonstrating that in class inclusion taxonomies of common concrete nouns in English, basic objects are the most inclusive categories whose members: (a) possess significant numbers of attributes in common, (b) are used by means of similar motor programs, (c) possess shapes which are significantly similar, and (d) can be identified from averaged shapes of the members of the class. For all of the taxonomies studied, there was a level of abstraction at which all of these factors co-occurred and below which further subdivisions added little information. In all four respects, basic objects were the categories for which cue validity and, thus, differentiation between categories at that level of abstraction was maximized; categories at higher levels of abstraction than the basic possessed few attributes, motor programs, etc. in common; categories subordinate to the basic shared most attributes with contrasting subordinate categories.

The eight experiments reported in Part II were designed to explore some of the implications of basic objects. With respect to the nature of cognitive codes, basic categories were shown (by the converging techniques of signal detection and priming) to be the most abstract categories which could be represented by a code which was isomorphic to the appearance of objects of the class--such a code is commonly called an image. Regarding perception, it was demonstrated, by means of verification of category membership of pictures of objects, that objects appear to be first seen or recognized as members of their basic category; additional processing appears to be required to identify superordinate or subordinate category membership. With respect to development, children were shown to sort basic objects taxonomically at ages at which the superordinate sets usually supplied children in sorting experiments are largely sorted by complexive principles. With respect to language, basic object names were shown to be the most used by adults, the first used by children acquiring language, and the least dispensable in a language possessing fewer lexical items than standard English.

The concept of basic objects was discussed in terms of the universality of the results, the effects of human ignorance and expertise on classifications, and the relation of the principles of classification to cognitive prototypes. Some extensions of the theory of categorization to domains other than objects were discussed.

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Carolyn Mervis is now at Cornell University. She was a National Science Foundation predoctoral fellow during performance of the research.

With respect to the responsibilities of the co-authors: Carolyn Mervis was generally knowledgeable concerning the research and was helpful in some aspects of most of the experiments. Specifically, Mervis was most active in Experiments 1, 6, 8, and 9, and in helping to develop the coding system in Experiment 2; Gray was active in Experiments 3 and 4; Johnson in Experiments 11 and part of 2; Boyes-Braem in Experiment 12.

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Table 1

The Nine Taxonomies Used as Stimuli

Superordinate	Basic Level	Subordinates	
		Non-biological Taxonomies	
Musical Instrument	Guitar	Folk guitar	Classical guitar
	Piano	Grand piano	Upright piano
	Drum	Kettle drum	Base drum
Fruit[a]	Apple	Delicious apple	Mackintosh apple
	Peach	Freestone peach	Cling peach
	Grapes	Concord grapes	Green seedless grapes
Tool	Hammer	Ball-peen hammer	Claw hammer
	Saw	Hack hand saw	Cross-cutting hand saw
	Screwdriver	Phillips screwdriver	Regular screwdriver
Clothing	Pants	Levis	Double knit pants
	Socks	Knee socks	Ankle socks
	Shirt	Dress shirt	Knit shirt
Furniture	Table	Kitchen table	Dining room table
	Lamp	Floor lamp	Desk lamp
	Chair	Kitchen chair	Living room chair
Vehicle	Car	Sports car	Four door sedan car
	Bus	City bus	Cross country bus
	Truck	Pick up truck	Tractor-trailer truck
		Biological Taxonomies	
Tree	Maple	Silver maple	Sugar maple
	Birch	River birch	White birch
	Oak	White oak	Red oak

Table 1 (continued)

Fish	Bass	Sea bass	Striped bass
	Trout	Rainbow trout	Steelhead trout
	Salmon	Blueback salmon	Chinook salmon
Bird	Cardinal	Easter cardinal	Grey tailed cardinal
	Eagle	Bald eagle	Golden eagle
	Sparrow	Song sparrow	Field sparrow

[a] Fruit is not considered a biological taxonomy by the criteria in Berlin (1972).

Table 2

Number of Attributes in Common at Each Level of Abstraction

Category	Number of attributes in common					
	Raw Tallies			Judge-amended Tallies		
	Superordinate	Basic level	Subordinate	Superordinate	Basic level	Subordinate
	Non-biological Taxonomies					
Musical instrument	1	6.0	8.5	1	8.3	8.7
Fruit	7	12.3	14.7	3	8.3	9.5
Tool	3	8.3	9.7	3	8.7	9.2
Clothing	3	10.0	12.0	2	8.3	9.7
Furniture	3	9.0	10.3	0	7.0	7.8
Vehicle	4	8.7	11.2	1	11.7	16.8
	Biological Taxonomies					
Tree	9	10.3	11.2	10	11.0	11.5
Fish	6	8.7	9.3	8	9.7	10.0
Bird	11	14.7	15.3	14	16.0	16.5

Table 3

Number of Motor Movements in Common at Each Level of Abstraction

Category	Number of motor movements in common				
	Super-ordinate	Basic Level	Subordinate mean	Subordinate number added	Subordinate number subtracted
		Non-biological taxonomies			
Musical instrument	0	16.7	16.2	2.2	2.6
Fruit	4	21.3	20.5	2.5	3.3
Tool	2	19.2	18.0	1.2	2.7
Clothing	2	19.0	19.2	1.5	1.5
Furniture	1	11.7	12.3	1.3	.7
Vehicle	1	18.0	18.2	2.8	2.5
		Biological taxonomies			
Tree	8	6.0	6.8	.7	.8
Fish	17	14.0	17.0	1.2	1.7
Bird	7	7.3	7.2	.3	.5

Table 4

Specificity Count at Each Level of Abstraction

Category type	Mean number of movements		
	Superordinate	Basic level	Subordinate
Non-biological	18.2	49.0	45.3
Biological	28.3	25.7	22.0

Table 5

Classifications of Stimuli Used in Experiments 3 and 4

Superordinate	Basic Level
Clothing	pants, shirt, shoes, socks
Vehicle	car, truck, airplane, motorcycle
Animals[a]	cat, dog, fish, butterfly
Furniture	chair, table, sofa, bed

[a] For an objective measure of shape, the confusion between the terms animal and mammal in English is not relevant.

Table 6

Mean Reaction Times (Msec) for Verification of Category Membership of Objects

Response type	Type of name		
	Superordinate	Basic level	Subordinate
True	591	535	659
False	630	578	642

Table 7

Type of Name Given in Free Naming of Pictures

Contrast set	Type of Name given			
	Superordinate	Basic level	Subordinate	Other
Superordinate	0	532	5	2
Basic level	0	533	4	2
Subordinate	1	530	5	4

Table 8

Concrete Nouns used in Stage I of Language Acquisition

Category	Taxonomic level of word used					
	Superordinate		Basic level		Subordinate	
	Tokens[a]	Types[a]	Tokens	Types	Tokens	Types
			Non-Biological			
Musical instrument	0	0	13	6	0	0
Fruit	0	0	7	3	0	0
Tool	0	0	37	13	0	0
Clothing	2	1	91	18	4	1
Furniture	0	0	75	16	1	1
Vehicle	0	0	50	11	3	2
			Biological[b]			
Tree	0	0	0	0	0	0
Fish	19	1	0	0	0	0
Bird	13	1	0	0	0	0

[a] The token count is the total number of utterances of any word of that classification; the type count is the number of different words in the classification which were used.

[b] The level shown as superordinate matches Table 1 but is the level shown to be the basic level for biological taxonomies in the earlier experiments.

Table 9

Percent of Items having Consistent Signs or Sign Combinations in ASL

Category type	Taxonomic level		
	Superordinate	Basic level	Subordinate
Nonbiological	33	90	8
Biological[a]	100	22	0

[a] The level shown as superordinate matches Table 1 but is the level shown to be the basic level for biological taxonomies in the earlier experiments.

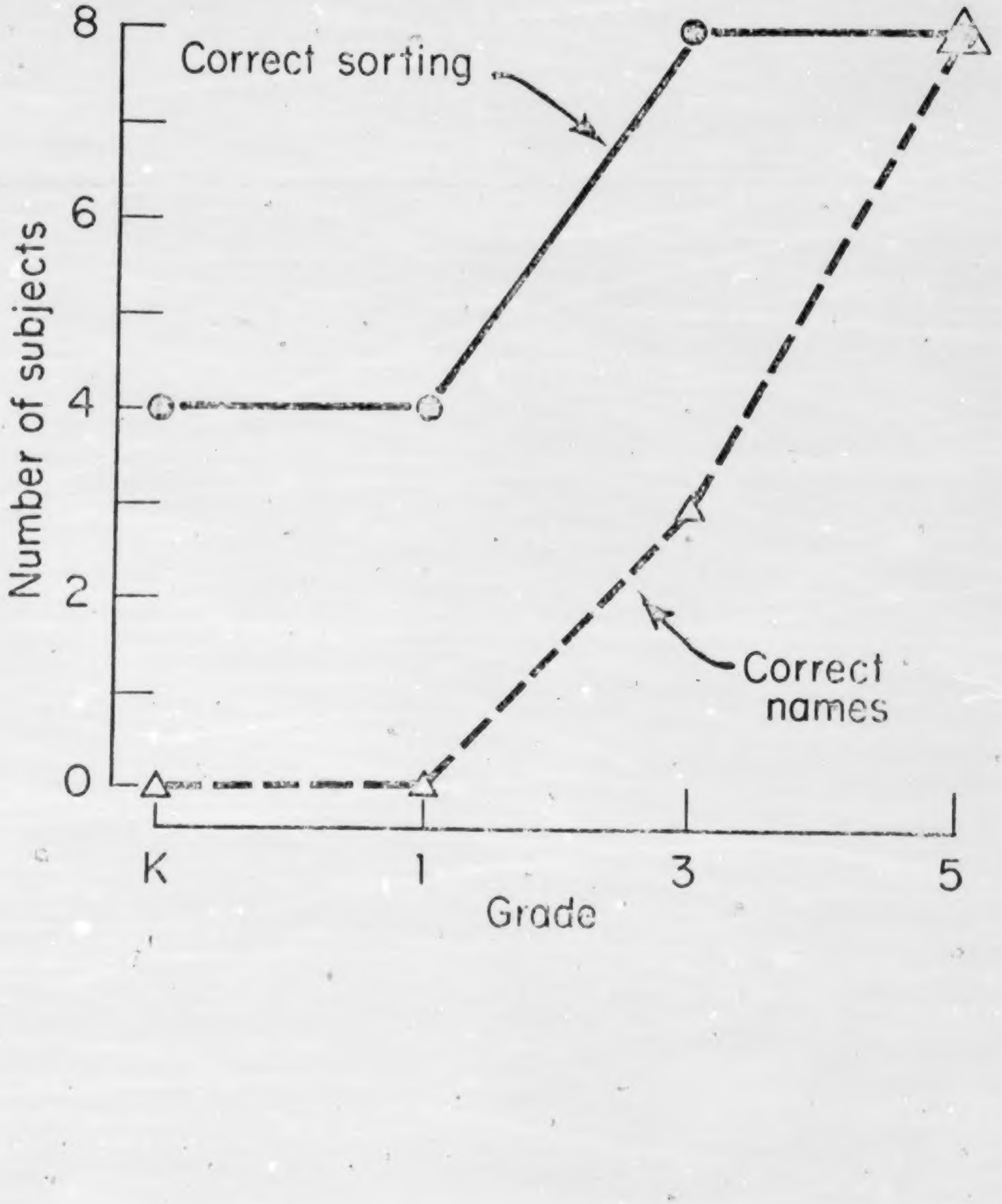
Figure captions

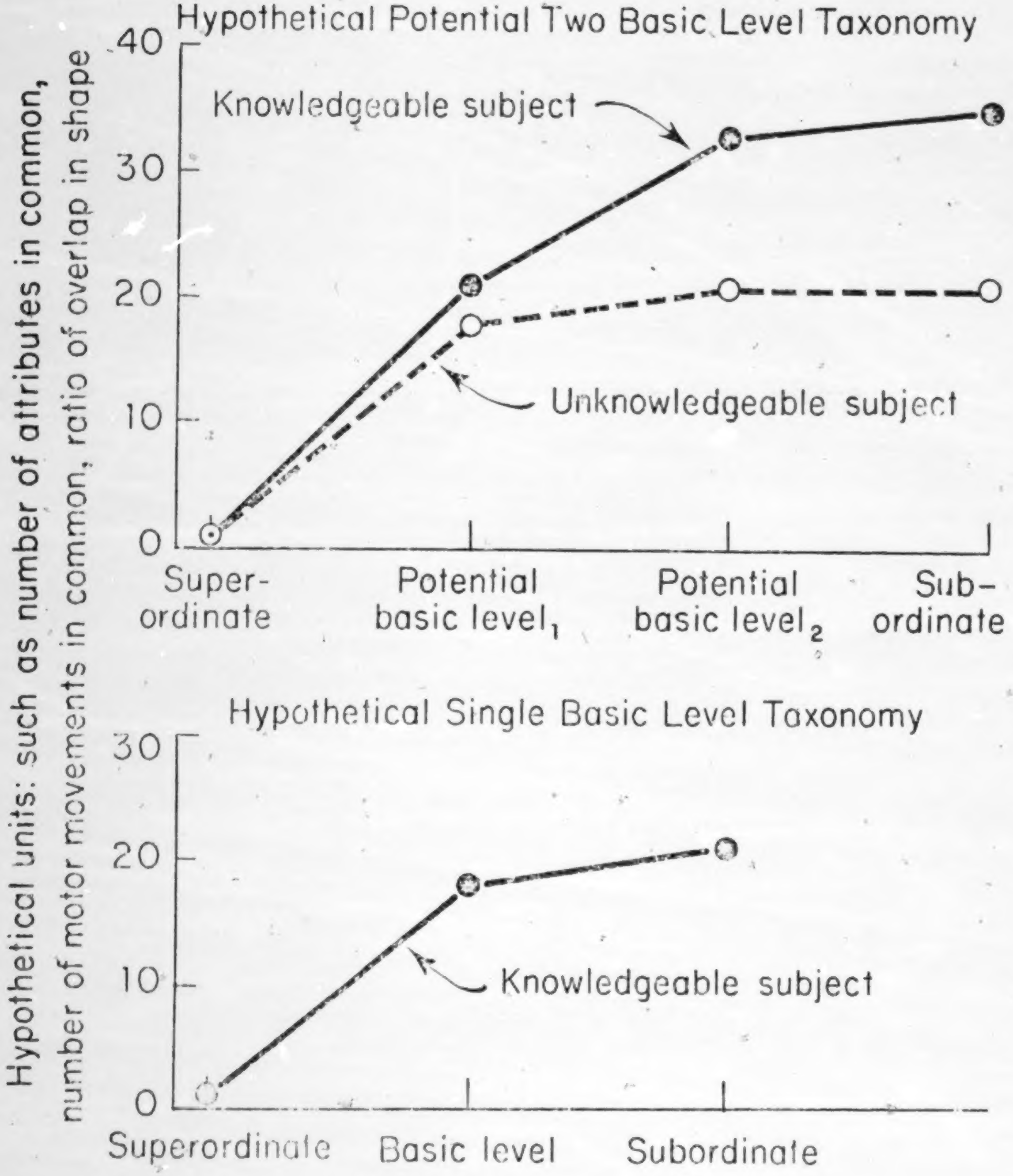
Figure 1. Examples of traced outlines of pictures used in Experiment 3. One example of each basic level object from each superordinate category is shown.

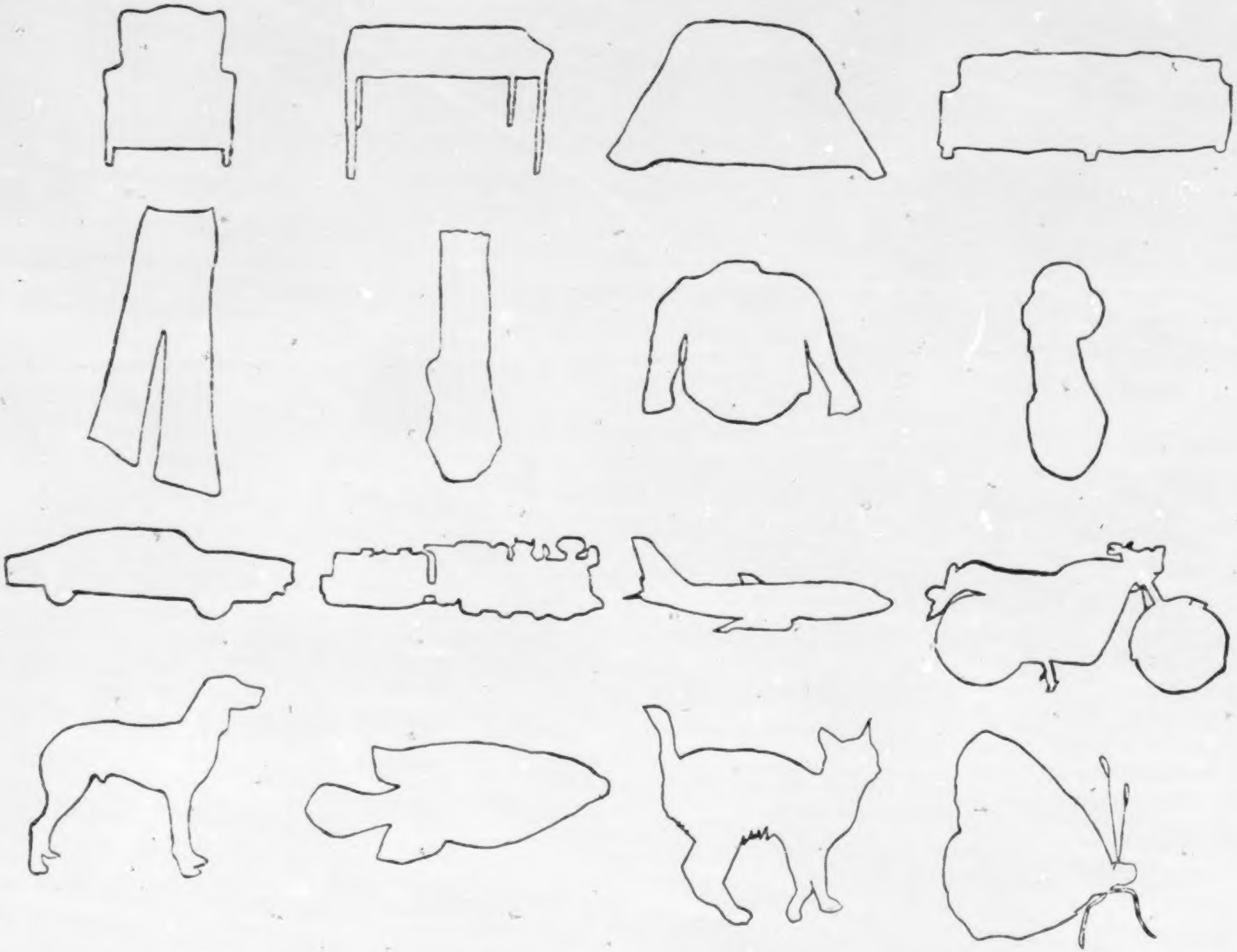
Figure 2. Correct sorting and correct reasons in the triads task of Experiment 8.

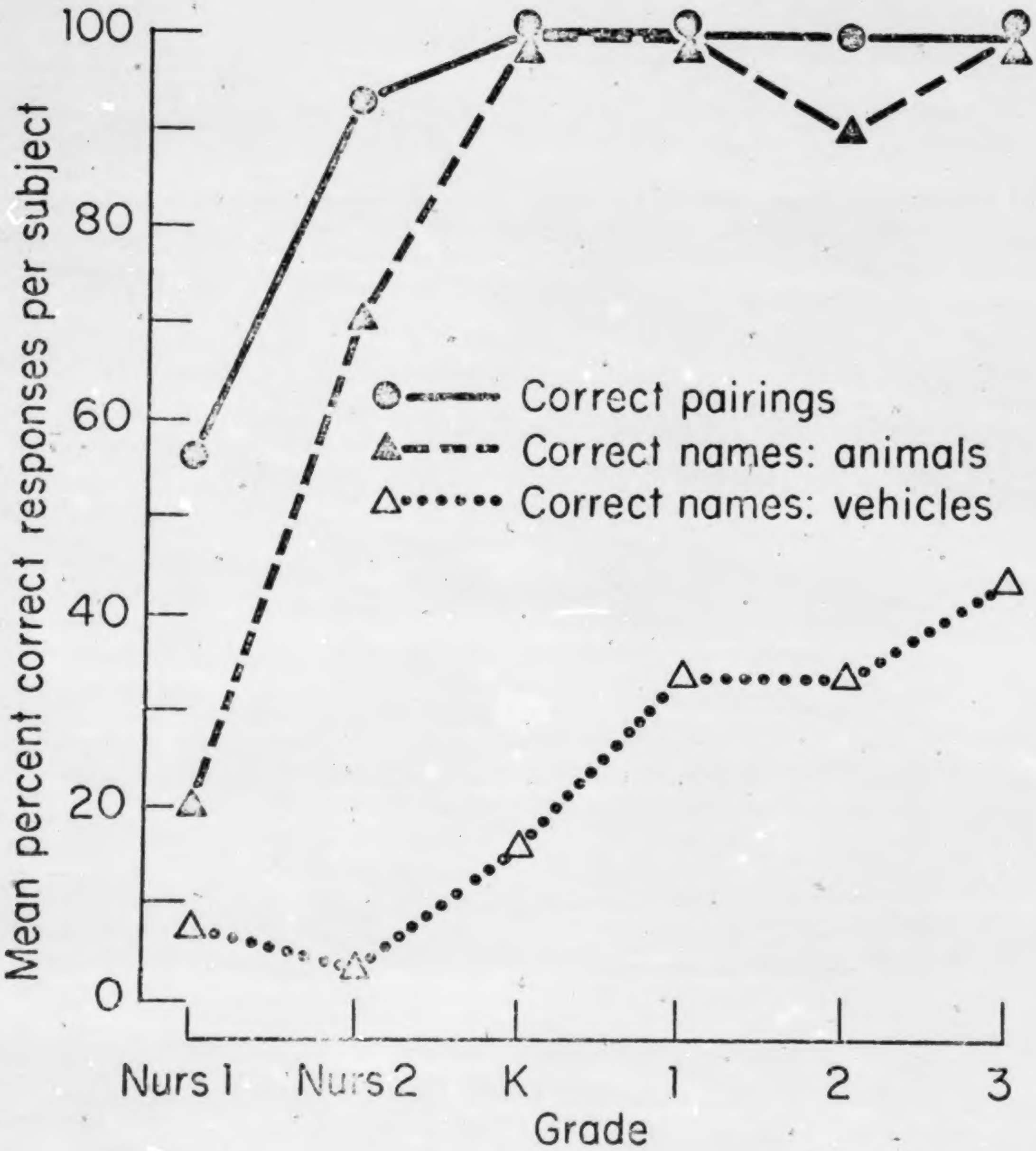
Figure 3. Correct sorting and correct reasons in the sorting task of Experiment 9.

Figure 4. Hypothetical one- and two-level taxonomies.


8
6
4
2
0
Number of subjects
Correct sorting
Correct names
K
1
3
5
Grade


Hypothetical Potential Two Basic Level Taxonomy
40
30
20
10
0
Knowledgeable subject
Unknowledgeable subject
Super-ordinate
Potential basic level$_1$
Potential basic level$_2$
Sub-ordinate
Hypothetical Single Basic Level Taxonomy
30
20
10
0
Knowledgeable subject
Superordinate
Basic level
Subordinate
Hypothetical units: such as number of attributes in common, number of motor movements in common, ratio of overlap in shape




100
80
60
40
20
0
Mean percent correct responses per subject
Correct pairings
Correct names: animals
Correct names: vehicles
Nurs 1
Nurs 2
K
1
2
3
Grade

Basic objects
A1-1

Appendix I

Judge-amended Attributes for Each Item in the Nine Taxonomies

Note: Lower levels include all attributes listed at higher levels.

SUPERORDINATE	BASIC LEVEL		
Musical instrument	Guitar	piano	Drum
makes sounds	strings	keys	sticks
	tuning keys	foot pedals	skins
	neck	strings	round
	hole	legs	loud
	wood	lid	used by music groups
	makes music	wood	
	you strum it	black keys	
	used by music groups	white keys	
		makes music	

SUBORDINATE

Classical guitar	Upright piano	Kettle drum
no additional	no additional	no additional
Folk guitar	Grand piano	Base drum
no additional	large used in concert halls	no additional

Basic objects
A1-2

SUPERORDINATE	BASIC LEVEL		
Fruit	Apple	Peach	Grapes
seeds	stem	pit	juicy
sweet	core	skin	bunches
you eat it	skin	yellow-orange	makes wine
	juicy	fuzzy	grows on vine
	round	soft	
	grows on trees	grows on trees	

SUBORDINATE

Declcious apple	Freestone peach	Concord grapes
red	no additional	purple
crisp		
shiny		
tasty		
Macintosh apple	Cling peach	Green seedless grapes
no additional	juicy	green
	canned	small

Basic objects
A1-3

SUPERORDINATE		BASIC LEVEL	
Tool	Hammer	Saw	Screwdriver
make things	handle	handle	handle
fix things	head	teeth	tip
metal	to nail	blade	it screws
	wooden handle	sharp	
	metal head	cuts	
		edge	
		wooden handle	

SUBORDINATE

Ball-peen hammer	Cross-cutting hand saw	Phillips screwdriver
no additional	used in construction	four-edged tip
Claw hammer	Hack hand saw	Regular screwdriver
to pull out nails	no additional	no additional

Basic objects

A1-4

SUPERORDINATE		BASIC LEVEL	
Clothing	Pants	Socks	Shirt
you wear it	legs	heel	sleeves
keeps you warm	buttons	toe	collar
	belt loops	cotton	pocket
	pockets	wool	cuff
	cloth	multicolored	buttons
	two legs	worn on feet	cotton
		come in pairs	
		SUBORDINATE	
	Levis	Knee socks	Dress shirt
	blue	long	no additional
		stretch	
	Double knit pants	Ankle socks	Knit shirt
	comfortable	white	stretches
	stretchy		comfortable

Basic objects
A1-5

SUPERORDINATE	BASIC LEVEL		
Furniture	Table	Lamp	Chair
no attributes	legs	light bulb	legs
	top	shade	seat
	surface	cord	back
	wood	switches	arms
	you eat on it	base	comfortable
	you put things on it	gives light	four legs
		you read by it	wood
			holds people-- you sit on it

SUBORDINATE

Kitchen table	Floor lamp	Kitchen chair
chairs	no additional	no additional
Dining room table	Desk lamp	Living room chair
four legs	no additional	large
		soft
		cushion

Basic objects
A1-6

SUPERORDINATE		BASIC LEVEL	
Vehicle	car	bus	truck
used for transportation	wheels	wheels	wheels
	doors	driver	doors
	engine	seats	steering wheel
	seats	doors	tires
	trunk	engine	windows
	steering wheel	windows	seats
	speedometer	gears	driver
	windshield	windshield	engine
	windows	tires	cab
	gears	steering wheel	gears
	tires	speedometer	windshield
	four wheels	aisle	four wheels
	requires gas	passengers	large
		four wheels	noisy
		large	
		requires gas	

SUBORDINATE

Sports car	Cross country bus	Pick-up truck
stickshift	no additional	no additional
fast		
small		
Four-door sedan	**City bus**	**Tractor-trailer truck**
radio	no additional	bed
four doors		
regular seats		

Basic objects
AI-7

SUPERORDINATE

Tree

leaves
roots
branches
trunk
bark
wood
sap
tall
gives shade
home for
animals &
insects

BASIC LEVEL

Maple	Birch	Oak
no additional	white bark	acorns
		large

SUBORDINATE

Silver maple	River birch	White oak
no additional	green	no additional
	grows near river	

Sugar maple	White birch	Red oak
green	no additional	no additional
we use sap		

Fish

gills
scales
fins
eyes
tail
mouth
swims
lives in
water

BASIC LEVEL

Bass	Trout	Salmon
big	lives in lakes	food
food	food	

SUBORDINATE

Sea bass	Rainbow trout	Blue back salmon
lives in ocean	rainbox	no additional

Striped bass	Steelhead trout	Chinook salmon
striped	no additional	no additional

Basic objects
A1-8

SUPERORDINATE		BASIC LEVEL	
Bird	Cardinal	Eagle	Sparrow
feathers	red	big	small
wings		U.S. emblem	brown
beak		becoming extinct	
legs		SUBORDINATE	
feet	Grey-tailed cardinal	Bald eagle	Song sparrow
eyes			
tail	grey tail	no additional	no additional
head	Easter cardinal	Golden eagle	Field sparrow
claws	no additional	preys	no additional
lays eggs		golden	
nests			
flies			
chirps			
eats worms & flies			

Note: in this appendix, it may be observed that not all attributes are true for every imaginable instance of the class. For a discussion of this point, see the General Discussion of Part II of the present paper (Rosch et al, Note 1).

Appendix II

Motor Movements for Each Item in the Nine Taxonomies

SUPERORDINATE

Musical instrument

none

BASIC LEVEL--Activity is play

Guitar

- Hand: grasp
  - position
- Knees-thighs: support weight
- Elbow: bend
- Arm: extend
- Fingers-hand: bend
  - press
  - strum
  - pluck
  - position
  - move up & down
- Arm: move up & down
- Hand: move sideways
  - position

Piano

- Fingers: extend
- Legs: position
- Waist: bend
- Back: straighten
- Fingers: position
  - tense
  - press
- Wrist: bend
- Arms: move sideways
  - move up & down
  - bend
  - extend
- Back: bend
- Body: sway
- Feet: press
  - release
- Hand: tense
  - raise
  - lower
- Eyes: scan-read

Drum

- Fingers: grasp
- Arms: raise
  - position
- Hand: grasp
  - raise
  - lower
- Wrist: flex (up & down)
- Fingers: flex "
- Back: tense
  - relax
- Arm: raise
  - lower
  - tense
  - relax
- Head: move
- Elbow: bend

SUBORDINATE

Classical guitar

a +Knee: bend

Grand piano

+arm: lift

Kettle drum

+arms: lower

Basic objects

A2-2

+ hand: lift
+fingers:extend
+ neck: turn
- Hand: move sideways

2 -waist: bend
+arms: position
+fingers: move up
& down
-hand: tense

-back:tense
-back: relax
-arm: relax

Folk guitar
+head: bend
-knees-thighs:
support weight
+fingers: grasp
- hand: move sideways

Upright piano
-fingers: extend
+ fingers: bend
-fingers: tense
-back: straighten
-wrist: bend

Base drum
+fingers: stroke
+arm: stroke
-head: mov
-arm:tense
-arm:relax

SUPERORDINATE

Fruit
Hand: grasp
Mouth-teeth:
bite
chew
Mouth-throat:
swallow

BASIC LEVEL--Activity is eat

Apple
Hand: grasp
Elbow: bend
(Fore)arm: raise
bite
Mouth-lips: open
Teeth: open
Jaw-teeth: protrude
forward (into apple)
Tongue: retract
Jaw-teeth: apply
pressure
grasp
move together.
(close)

Peach
peel
Hand: flat
Fingers: position
knife
pinch
pull
Wrist: twist
eat
Hand: grasp
Elbow: bend
Arm: raise
Fingers: turn
bite
Mouth-lips:open

Grapes
Hand: hold
Fingers: grasp
pull
Wrist: pull
Arm: pull
Elbow: bend
Arm: raise
Hand: raise
bite
mouth-lips: open
Fingers: fondle
release
drop in grape
Mouth-teeth: close

Basic objects

A2-3

Jaw-head:
pull back
chew
Mouth-teeth-jaws:
move together
move apart
repeat
Tongue: move food
around
swallow
Mouth-jaw:tense
Throat-esophagus:
open
close
Mouth-throat:
swallow
Elbow: bend
Hand: move to
mouth

Mouth-throat:
suck juice
Jaw: open
close
chew
Mouth: open
close
repeat
Tongue: move food
swallow

chew
Mouth-teeth-jaws:
open
close
repeat
Tongue: move food
Throat: swallow

CODING OF ACTUAL
MODEL

+fingers: manipulate
+wrist:bend
pull

SUBORDINATE

Delicious apple
+fingers: grasp
-mouth-teeth:
protrude forward
-Jaw-head: pull
back
-repeat
+hand: rotate apple

Freestone peach
-fingers: pinch
turn
+ arm: extend
+hand: shake (juice)
-hand: grasp
+hand: rotate
-fingers: turn

Concord grapes
+hand: position
-wrist: pull
+jaw: lower
-fingers: fondle
+chest: blow
+lips: spit seeds

Basic objects
A2-4

-tongue: move
+head: bend

Macintosh apple
+fingers: rub
-tongue: retract
-jaw-head: pull
back
-repeat

Cling peach
+arm: extend
-hand:flat
-fingers: position
knife
-fingers: pinch
-fingers: pull
+eyes: scan

Green seedless grapes
+hand: extend
+fingers: turn
twist
-wrist: pull
-fingers: fondle

SUPERORDINATE

BASIC LEVEL Activity is use

Tool
Hand: grasp
Fingers: grasp

Hammer
Arm: extend
Hand: big grasp
position
Fingers: position
Other hand:position
Body: bend
Neck: bend
Eyes: focus
Scan
Arm: raise
Shoulder: twist
Elbow: bend
Arm: lower
Hand: lower
Wrist: tense

Saw
Arm: extend
Wrist: turn
Hand: grasp
Fingers: grasp
bend
position
Arm: position
Legs: position
Apart (spread)
Other hand:position
hold
Other arm: position
Shoulder: position
Back: bend
Body: brace

Screwdriver
Hand: grasp
Fingers: manipulate
rotate
position
Other hand:
position dcrew
Eyes: focus
Hand: position
insert tool
press
Arm: press
Wrist: turn(repeated)
Hand: turn (repeated)

Basic objects
A2-5

Arm: up & down
Hand: up & down
Elbow: keep bending
Shoulder: keep turning
Wrist: keep flexing

CODING OF ACTUAL MODEL

+fingers: manipulate
+other hand: manipulate
+muscles: tense

Eyes: scan-focus
Arm: exert pressure
pull back
Elbow: bend
Shoulder: move back
Arm: move forward
Elbow: bend
Shoulder: forward
back & forth
Arm: back & forth
Hand: back & forth
Elbow: back & forth

SUBORDINATE

Ball-peen hammer

+fingers: big grasp

Crosscut hand saw

+eyes: pursue
-shoulder: position
- back & forth

Phillips screwdriver

-fingers: manipulate
-eyes: focus
-arm: press
+hand: slip
+body: push
+shoulder: push

Claw Hammer

-wrist: keep flexing

Hack hand saw

-other arm: position
-shoulder: position
- move forward
move back
move back & forth

Regular screwdriver

-fingers: manipulate
-eyes: focus
+ elbow: bend

Basic objects
A2 6

+hand: shake
-arm: pull back
-elbow: back & forth

SUPERORDINATE

Clothing
Eyes: scan
Hand: grasp

BASIC LEVEL Activity is put on

Pants
Hands: grasp
Arms: extend
Back: bend
Feet: position
Knee: bend
Leg: raise
extend
Foot: raise
extend
Hand: raise
extend
Knee: bend
Leg: raise
extend
Hands: extend
raise
Fingers: grasp
Elbows: bend
Arms: pull up
Fingers: grasp
pull up
twist

Socks
Hand: grasp
Body: bend
Neck: bend
Leg: raise
Knee: bend
Hand: grasp
Fingers: grasp
pull apart
Foot: position
Toe: position
extend
Foot: extend
Hand: turn
Wrist: bend
Hand: pull
Arm: pull
Elbow: bend
Leg: extend

CODING OF ACTUAL MODEL -
+head:hang down
+fingers: manipulate

Shirt
Hand: grasp
Arms: raise
position
Head: bend back
Elbow: bend
Hand: insert
extend
Arm: extend
Hand: pull
Body: turn
Elbow: bend
Hand: extend
Arm: extend
Elbows: bend
Fingers: grasp
twist
button

Basic objects
A2-7

SUBORDINATE

Levis

+toes: extend
+butt: wiggle

Knee socks

-hand: grasp
+arm: move up & down (smoothing)

Dress shirt

+arm: grasp
+hand: extend
-elbow: bend
+shoulders: tense
+neck: stretch & wiggle

Double knit pants

-fingers: pull up

Ankle socks

+eyes: scan
+hands: search
-hand: grasp
-fingers: pull apart
-elbow: bend

Knit shirt

+arms: lower
-head: bend back
-hand: insert
-body: turn
-fingers: button

SUPERORDINATE

Furniture

Eyes: scan

BASIC LEVEL

Table

approach
Feet: step
Put thing on it
Hands: grasp
Fingers: grasp
Arms: extend
lower
bend
Fingers: release
Hands: move apart

Lamp

turn it on
Arm: extend
bend
Elbow: bend
Hand: extend
position
Fingers: grasp
squeeze-
exert pressure
turn
Wrist: turn
Hand: turn

Chair

sit on
Head: turn
Body: turn
move back
position
Knees: bend
Arm: extend-touch
Waist: bend
Butt: touch
Waist: bend
Body-legs:
release weight

Basic objects
A2-8

Back-torso:

straighten

lean back

move

back: bend

hands: grasp

arms: tense

body: raise

ACTUAL CODING OF MODEL--sit

-head turn

+feet turn

+legs touch

-arm: extend

+body: squirm

SUBORDINATE

Kitchen table	Floor lamp	Kitchen chair
+hands: position	+arm: raise	-head: turn
+ slide	-arm: bend	Move
+Body: move back		+elbow-arms:pull back
		+legs: move back
		-arms: tense

Dining room table	Desk lamp	Living room chair
-feet: step	+elbow: rest	+body: sink

Basic objects
A2-9

SUPERORDINATE

Vehicle

drive

- Arms: pull

BASIC LEVEL

Car

drive

- Hand: position
  - grasp
  - turn
- Feet: position
  - press
  - release-
  - raise
- Head: turn
- Eyes: scan
- Arms: rotate

enter

- Arm: extend
- Hand: grasp
  - pull
  - press
- Fingers: press
- Elbow: bend
- Leg: raise
  - extend
- Head: bend
- Body: bend
- Butt: touch
- Leg:release weight
- Back: lean back

Bus

enter

- Knee: bend
- Leg: raise
- Foot: raise
  - press down
- Hand: grasp
- Body: shift weight
- Back: bend
  - straighten

sit

- body: turn
- Legs: move sideways
- Knees: bend
- Body: lower

Truck

drive

- Hand: turn
- Wrist: turn
- Arm: turn
- Elbow: move
- Shoulder: bend
  - move
- Leg: bend
  - extend
- Foot: extend
  - press
  - raise
- Eyes: scan

enter

- Knee: bend
- Leg: raise
- Foot: bend
- Arm: extend
  - raise
  - pull up
- Finger-hand: grasp
- Body: leap up

Basic *objects*

A2-10

SUBORDINATE

Sports car

+elbow: bend

+elbow: straighten

+feet: bend

+eyes: shift

enter

-hand: press

+butt: swing in

+legs: swing in

-leg: raise

-- extend

-back: lean back

Cross country bus

sit

+hand: grasp

+body: release weight

-legs: move sideways

Pick-up truck

drive

+hand: grasp

-wrist: turn

-elbow: move

-foot: extend

-leg: bend

enter

+hand extend

+fingers: press

Four door sedan

drive

+fingers: press

Enter

-hand: press

-release weight

City bus

enter

+hand: extend

sit

+eyes: scan

-body: lower

Tractor trailer truck

enter

-leg: raise

+foot: press

+foot: position

SUPERORDINATE

Tree

climb

Arm: extend

Hand: grasp

Leg: raise

Knee: bend

Arms: pull

Leg: support weight

BASIC LEVEL

Maple tree

climb

Hand: grasp

Leg: raise

Knee: bend

Leg: support weight

look at

eyes: scan

Birch tree

climb

Arm: extend

Hand: grasp

Leg: raise

Knee: bend

Arm: pull

Body: shift weight

Oak tree

climb

Arm: extend

Hand: grasp

Leg: raise

Knee: bend

Arm: pull

Legs: push

Body: shift		look at	look at
weight		Eyes: scan	Eyes: scan
look at		Head: tip back	Head: raise
Eyes: scan			

SUBORDINATE

Silver maple	River birch	White oak
climb	climb	climb
+arm: extend	-arms: pull	+body:turn
	+legs: push	
	look at	
	-head: tip back	
Sugar maple	White birch	Red oak
climb	climb	climb
-leg: raise	-arms: pull	-legs: push
	+legs: push	

SUPERORDINATE		BASIC LEVEL	
Fish	Bass	Trout	Salmon
watch	watch	watch	watch
Eyes: scan	Eyes: scan	Eyes: scan	Eyes: scan
pursue	pursue	pursue	pursue
lower	lower	lower	eat
eat	eat	eat	mouth-teeth:
Mouth-teeth:	mouth-teeth:	mouth-teeth:	bite
bite	bite	bite	chew
chew	chew	chew	swallow
open	open	open	fish
close	close	close	Hand: grasp

Basic objects
A2-12

Mouth-throat:
swallow
fish
Hand: grasp
Elbow: bend
Arm: extend
raise
pull
Hand: pull-
push
rotate
(wind)
Wrist: rotate
Fingers:
rotate

Mouth-throat:
swallow
fish
Hand: grasp
Elbow: bend
extend
Arm: extend
raise
pull
Hand: push-
pull
Wrist: rotate
Fingers: rotate

Mouth-throat:
swallow
fish
Hand: grasp
Elbow: bend
Arm: extend
raise
Hand: pull
rotate

Elbow: bend
Arm: extend
raise
Hand: rotate

SUBORDINATE

Sea bass
fish
-elbow: extend
-fingers: rotate

Rainbow trout
eat
-mouth:open
-mouth:closed
fish
+hand: move
back & forth
+arm: swing back
-hand: rotate

Blue back salmon
eat
+mouth: open
fish
+back: pull

Striped bass
eat
-mouth: open
-mouth: close

Steelhead trout
watch
+head: bend

Chinook salmon
fish
+arm: pull

watch

-eyes: lower

+nose: press

fish

-elbow: extend

-wrist: rotate

SUPERORDINATE		BASIC LEVEL	
Bird	Cardinal	Eagle	Sparrow
look at	look at	look at	look at
Eyes: scan	Eyes: scan	Eyes: scan	Eyes: scan
pursue	pursue	pursue	pursue
look up	blink-	blink-	look up
squint	squint	squint	look down
(blink)	look up	look up	Head: pursue
Head: turn	look down	Head: turn	turn
pursue	Head: turn	tip back	tilt back
Neck: tip back	pursue	pursue	
	tip back		

SUBORDINATE

Grey-tailed cardinal	Bald eagle	Song sparrow
-eyes: look down		+eyes: focus
Easter cardinal	Golden eagle	Field sparrow
+eyes: focus		-eyes: look up
		-head: tilt back

[a] Movements tallied for subordinate classes are the same ones listed in this appendix for the basic level unless otherwise indicated--"+" indicates a movement which was tallied for the subordinate class that had not been listed for the basic level of that class.

[b] "-" indicates a movement which failed to be tallied for the subordinate class which had been listed for the basic level of that class.